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SPONDYLOLISTHESIS

TREATMENT BY ANTERIOR BONE GRAFT

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Although somewhat confusing and laborious, a detailed study of the human spine must be the basic factor in an understanding of certain of its clinical disorders. The one selected for discussion here is spondylolisthesis, a condition or anomaly formerly mentioned only as occurring in women because of its relation to maternal dystocia. Recent investigation has sought the cause of pain and disabilities affecting the lower part of the back, which result in difficulties in awarding compensation when the condition is directly associated with the traumas of occupation or when distress and restricted activity are chronically prolonged exclusive of a known trauma. In the course of this investigation the condition and its alleviation have become prominent in surgical research. The advent of high grade roentgenologic aid in the clinical study of the human spine has added to knowledge of the anatomic and pathologic character of these formerly obscure conditions affecting the vertebrae. For decades anatomic research has been undertaken in this subject, but it has not been well coordinated with clinical records describing the nature of the complaint and the results of examination. The studies of Dwight, Willis, Kilian, Neugebauer, Rosenberg, Goldthwaite, Lord and others have received scant attention from the clinical surgeon, whose interest in the fascinating study of the spine was perhaps finally aroused by Schmorl's intensive research on his vast anatomic collection.[1]

Spondylolisthesis was first named by Kilian in 1852, but it had been described by Herbineau in 1782, Rokitansky in 1839 and Belloc in 1849. After Neugebauer's published report of 101 cases in 1892, largely composed of observations on museum specimens, attention to the subject slumped, although isolated instances of operative treatment

1. Schmorl, G.: Archiv und Atlas der normalen und pathologischen Anatomie in typischen Röntgenbildern. Die gesunde und kranke Wirbelsäule im Röntgenbild: Pathologisch-anatomische Untersuchungen, Leipzig, Georg Thieme, 1932, p. 182.

appeared, such as that of Ryerson, in 1915.[2] A most satisfying study of the lumbosacral part of the spine formed a part of Theodore A. Willis' thesis at Western Reserve University in June 1922.[3] He assumed a normal vertebral formula of seven cervical, twelve thoracic, five lumbar, five sacral and four coccygeal segments, with variations. The cervical vertebrae remain approximately constant; the coccygeal segments may vary but are of negligible importance on account of their vestigial nature.[4] The greatest clinical interest lies in the thoracolumbar group, which may be associated with phylogenetic changes affecting the progression or retrogression of the leg on the spinal column in the change from pronograde to orthograde ambulation.[5] This thoracolumbar group must be considered as a unit. Willis stated that variation in the number of lumbar vertebrae is often found to be coincident with or compensated by a reverse variation in the thoracic group, the total number of presacral segments remaining unchanged. The modal number of human thoracolumbar vertebrae is seventeen; and of 748 columns examined by Willis only 5 showed sixteen and 26 showed eighteen. The remaining 772 showed the modal number, the numerical stability of the presacral segments being 95.8 per cent.

A definition of spondylolisthesis was given by Ziegler:[6] "It is a deformity in which by the action of the weight of the trunk, the body of the 5th lumbar vertebra and the portion of the spinal column above it slip forward over the base of the sacrum." The term means slipping vertebra. In true spondylolisthesis the arch of the fifth lumbar or other vertebra concerned, with its spinous process, does not take part in the spondylolisthesis, the anterior part or body of the vertebra alone being displaced. If the whole vertebra is set forward, lifted over the hump of the supporting facets on the base of the sacrum, the condition is known as pseudospondylolisthesis and represents a true dislocation or subluxation. Schmorl found among the spines in his material 46 instances of true spondylolisthesis (25 in women and 21 in men) and 14 of pseudospondylolisthesis (11 in women and 3 in men).

The cause for separation of the neural arch or its isthmus may be either traumatic violence, usually a shearing strain resulting in fracture, or anomalies of development in the laminas or isthmus, the inter-

2. Ryerson, E. W.: Recurrent Spondylolisthesis with Paralysis: Bone-Splint Transplantation, J. A. M. A. **64**:24 (Jan. 2) 1915.

3. Willis, T. A.: Lumbo-Sacral Vertebral Column in Man: Its Stability of Form and Function, Am. J. Anat. **32**:95 (July) 1923.

4. Mitchell, G. A. G.: Significance of Lumbosacral Transitional Vertebrae, Brit. J. Surg. **24**:147 (July) 1936.

5. Paterson, A. M.: The Human Sacrum, Proc. Roy. Soc. Med. **51**:520, 1892.

6. Ziegler, E.: Lehrbuch der allgemeinen und speciellen pathologischen Anatomie für Aerzte und Studierende, ed. 9, Jena, Gustav Fischer, 1898, sect. 4, p. 219.

articular part of the neural arch, but generally is a failure of bony fusion, well described by Neugebauer in 1892.[7] Inflammatory reactions affecting predominately this area may possibly influence the separation of the arch. Constriction lines of the isthmus were noticed by Poirier,[8] and a definite division of the lamina was reported by Shore [9] in 1929 in an African native woman. In the same year, Brailsford,[10] after roentgen examination of more than 3,000 backs, found only 5 instances of spondylolisthesis, of which 3 were in girls 13, 15 and 17 years of age, 1 in a boy of 17 and 1 in a man of 35. He reviewed the 5 cases reported by Turner and Tchirkin [11] and considered that only 1 of the group was an instance of real spondylolisthesis. Hibbs and Swift,[12] reporting operation on 23 patients in group III of their compilation found forward displacement of the 5th lumbar vertebra varying from ¼ inch (0.6 cm.) to the full width of the corpus, along with a separation of the laminas and loss of the bony anchorage which would prevent the fifth lumbar vertebra and the superimposed spine from slipping forward. The ages of the patients varied from 15 to 51; 15 were men and 8 were women. The percentage of their cases in which there was a history of trauma was 47.8. Some separations of the isthmus may represent fractures sustained in childhood, unrecognized until strain in adult life produces symptoms following either a slow or a sudden slipping forward of the vertebra. There is no doubt that the isthmus, as described by Chandler [13] and others, is a vulnerable area of incomplete ossification which may permit many of these displacements.

When the neural arch of the fifth lumbar vertebra is unfused or separated, there may follow sooner or later a change in the axis of

7. Faldini, C.: Osservazioni cliniche e radiografiche sopra la spondilolistesia e la spondilolisi, Chir. d. org. di movimento **12**:545 (Sept.) 1928. Lane, W. A.: Spondylolisthesis, Tr. Path. Soc. London **36**:364, 1885. Lange, M.: Die Wirbelgelenke: Die röntgenologische Darstellbarkeit ihrer krankhaften Veränderungen und ihre Beziehungen zu den verschiedenen Erkrankungen der Wirbelsäule, ed. 2, Stuttgart, Ferdinand Enke, 1936, p. 80. Le Double, A. F.: Traité des variations de la colonne vertébrale de l'homme, Paris, Vigot-Frères, 1912, p. 314.

8. Poirier, P., and Charpy, A.: Traité d'anatomie humaine, ed. 3, Paris, Masson & Cie, 1911, vol. 1, p. 171.

9. Shore, L. R.: Report of a Specimen of Spondylolisthesis, Brit. J. Surg. **16**:431 (Jan.) 1929.

10. Brailsford, J. F.: Deformity of the Lumbo-Sacral Region of Spine, Brit. J. Surg. **16**:562 (April) 1929.

11. Turner, H., and Tchirkin, N.: Spondylolisthesis, J. Bone & Joint Surg. **7**:763 (Oct.) 1925.

12. Hibbs, R. A., and Swift, W. E.: Developmental Abnormalities at the Lumbosacral Juncture Causing Pain and Disability: Report of One Hundred and Forty-Seven Patients Treated by the Spine Fusion Operation, Surg., Gynec. & Obst. **48**:604 (May) 1929.

13. Chandler, F. A.: Lesions of "Isthmus" (Interarticularis) of Laminae of Lower Lumbar Vertebrae and Their Relation to Spondylolisthesis, Surg., Gynec. & Obst. **53**:273 (Sept.) 1931.

support of this vertebra on the sacrum. The upper borders of the superior articular surface of the sacrum were likened by Willis to the peak of a roof, one side formed by the base of the sacrum, which in an erect person presents an inclination of 45 degrees with the long vertical axis of the spine. The body of the fifth lumbar vertebra rests on this surface with the interposition of a wedge-shaped intervertebral disk, the broadest diameter of which lies anteriorly. The weight of the torso, head and arms must be supported on this precarious inclined surface held by the anchoring, hooklike inferior articular processes of the fifth lumbar vertebra engaged over the superior articular processes of the sacrum like a fireman's ladder. A large proportion of active support lies in the spinal muscles and some in the lumbosacral and interspinal ligaments, but there are times of relaxation or moments of strain when these sustaining factors are greatly lowered in value and the bony parts must take on a greater share of the support of the superimposed spine and torso as a whole. If a laminar (isthmian) defect is then encountered, the anteroposterior stability of the lumbosacral articulation is further endangered, and the column as a whole tends to slip downward and forward along the inclined plane of the superior surface of the sacrum.

Muscular fatigue, temporary overstrain and possible defective ligamentous support and bony anchorage readily explain spondylolisthesis. A unilateral defect in the lamina may not permit sufficient separation for this slipping, but weakness of one side of the neural arch may favor easy fracture of the opposite side or lead to favoring muscular and ligamentous relaxation. Usually the bony defect has been found to be bilateral. True spondylolisthesis will thus be almost impossible in the face of normal inferior articular processes and laminas of the fifth lumbar vertebra holding a normal relation with the sacrum. It is possible for the spine to sustain sufficient trauma, especially when flexed forward, rarely when hyperextended, to tear the inferior articular processes away from their attachments so as to let them ride up over the superior articular processes of the sacrum, an accident which causes pure dislocation. In this displacement, because the laminas and spinous process would go along with the corpus of the vertebra, pressure on the cauda or spinal nerves with resulting paralysis or lesions of the nerves may follow. Fracture of the laminas must be a simpler process in such an injury than a lifting over the obstacle of the sacral processes of all the weight above, held by strong, inelastic ligaments. Without bony lesion, the condition becomes pseudospondylolisthesis.

Following the forward displacement of spondylolisthesis must come easy tire in the lumbosacral area, pain, sometimes referred down both thighs and buttocks, stiffness in the back at that level, shortening of the spine, a crease across the back at or near the level of the iliac crests, a

palpable depression over the fifth or fourth lumbar vertebra and increase of lumbar lordosis. The abdomen becomes proportionately protuberant, and the gait may become waddling. A final proof of the diagnosis lies in the roentgenograms, the posteroanterior view showing the overlying shadow of the sacrum on the body of the fifth lumbar vertebra and the lateral view the projection forward of the fifth body and possibly the defect in the laminas. An ancient displacement will always show a liplike projection of new bone extending anteriorly from the superior surface of the visceral border of the sacrum, formed to help sustain the body of the fifth lumbar vertebra in its new position, unless the displacement has been so complete that the centrum of the fifth lumbar vertebra comes to lie completely displaced downward in front of the sacrum. Rarely the displacement is also lateral or has an acute scoliotic angle. In 12 of 18 instances of spondylolisthesis reviewed by Chandler the condition had an acute traumatic onset, and in 6 it followed repeated strains. The laminar defects generally involve the fifth lumbar vertebra alone but may include the fourth or, rarely, involve the fourth alone. In his report, Meyerding [14] mentioned one subluxation of the third on the fouth lumbar vertebra. The term spondylolisthesis is given also to any forward slipping at any level of the vertebral column accompanied by a laminar defect, whether congenital or acquired. Examples in the cervical and the dorsal region have been recorded. Other congenital or developmental defects may be present with this slipping. Spina bifida occulta is the one most frequently found, making up about 20 per cent.[15] Sacralization of the transverse process of the fifth lumbar vertebra, unilateral or bilateral, old osteoarthritis and local bone sclerosis, often mistaken for Paget's disease, may be present. In Meyerding's series of cases there were 71 per cent men and 29 per cent women suffering from this affliction.

The treatments offered are of interest after this brief investigation of cause and pathogenesis. In many instances spondylolisthesis is symptomless until aggravated by trauma. Treatment may be palliative for mild involvement, when an arrest of progressing deformity is desired, or it may be curative. The first consists of traction on head and feet in a position of recumbency. The feet are elevated to an angle of 35 or 40 degrees with the torso and subjected to all the traction they can withstand, counteraction being made on the head and beneath

14. Meyerding, H. W.: Spondylolisthesis, Proc. Staff Meet., Mayo Clin. **9**:666 (Oct. 31) 1934; Diagnosis and Roentgenologic Evidence in Spondylolisthesis, Radiology **20**:108 (Feb.) 1933; Spondylolisthesis, Surg., Gynec. & Obst. **54**:371 (Feb. 15) 1932; J. Bone & Joint Surg. **13**:39 (Jan.) 1931.

15. Putschar, W.: Changes in the Intervertebral Discs in Spondylolisthesis and Related Conditions of the Spine, Arch. Path. **24**:270 (Aug.) 1937. Stewart, T. D.: Spondylolisthesis Without Separate Neural Arch (Pseudo-Spondylolisthesis of Junghanns), J. Bone & Joint Surg. **17**:640 (July) 1935.

the axillas to pull the torso in the opposite direction. This procedure may effect partial reduction, especially after a recent gross displacement or even after several months, as in Jenkins' case.[16] He had his patient while lying in traction push down on the pelvic brim with his hands. The Sinclair net bed used in the treatment of fractures resulting from gunshot wounds in the femur or pelvis is an admirable means for this traction. If a reduction in whole or part can be effected, the patient may then be encased in plaster of paris, a double spica extending from the axillas to include both legs, for six or eight weeks. The cast may be followed by a steel back support in the corrected position. If the roentgenologic findings show the formation of much new bone about the lumbosacral junction, with no hope of reduction, traction may be omitted and the patient's back supported in a steel spinal brace in an attempt to prevent further displacement and to relieve fatigue.

For curative treatment, posterior spinal fusion has been done. Both the Hibbs and the Albee[17] method, with or without bone transplanted from the iliac crest or the tibia, have been employed. Many patients have obtained symptomatic relief, at least for a time, by these methods of posterior spinal fusion; whether this was permanent only years of observation and close follow-up could determine. Some operations have failed to relieve the pain and back fatigue.[18] Hibbs reported:

	Number of Operations	Percentage
Entirely relieved	16	66.7
Improved	3	12.5
Unimproved	5	20.8

Mathieu and Demirleau[19] advised an extensive osteosynthesis of the anterior segment of the lumbar vertebrae with the iliac bone, grafts from the ilium to the sacrolumbar bone on each side being used. With it is combined intervertebral and sacral synthesis, obtained by means of a sufficiently large graft to bridge through the posterior iliac crest into the transverse processes of the lumbar vertebra. Two grafts are used on each side, one reaching into that part of the fifth lumbar vertebra which is sliding (corpus) and the other extending from the ilium to the transverse process of the fourth lumbar vertebra to solidify that connection. The authors believe that these multiple arthrodeses combined with lumbosacral arthrodesis make ligamentous pull and resulting strain impossible. This is even a more extensive procedure than Chan-

16. Jenkins, J. A.: Spondylolisthesis, Brit. J. Surg. **24**:80 (July) 1936.

17. Albee, F. H.: Spondylolisthesis, J. Bone & Joint Surg. **9**:427 (July) 1927.

18. Hellström, J.: Zur Kenntnis der operativen Behandlung von Spondylolisthese, Acta orthop. Scandinav. **7**:143, 1936.

19. Mathieu, P., and Demirleau, J.: Traitement chirurgical du spondylolisthésis douloureux, Rev. d'orthop. **23**:352 (July) 1936.

dler's trisacral fusion, done from the posterior aspect of the spine. In the reproduced films of a patient on whom the operation Mathieu described was performed, the transplants do not seem large or sturdy enough to insure permanent immobilization, and on one side the transplant extending to the transverse process of the fourth lumbar vertebra does not seem bonily united. Hibbs and Swift stated: "It seems obvious that an operation which will produce strong bone fusion between the fourth and third lumbar vertebra and the sacrum is the logical procedure to employ in order to give stability to such a spine."

In 1932 Capener [20] reviewed this subject, including a study of 34 patients, and then suggested that the ideal fixation of the spine, mechanically efficient, would be one fixing the *body* of the fifth lumbar vertebra to the sacrum. However, if inserted transversely from the posterior aspect of the spine forward to form a supporting buttress of bone or bridge into the body of the fifth lumbar vertebra, it must go blindly and would probably injure the cauda. The attempt did not seem feasible, and his own words were: "The technical difficulties of such a procedure, however, preclude their trial." In July 1936 Jenkins recorded his case in New Zealand in which after reduction by traction he inserted a bone graft from the anterior surface of the body of the fifth lumbar vertebra into the sacrum after opening the abdomen. A successful result was obtained. In June 1933, Burns [21] reported a similar case of a boy of 14 who was operated on at St. Georges' Hospital and had an uneventful convalescence. In his brief report he mentioned that he did not believe that the invertebral disk is an ideal place for the bone graft and said that if in his case the graft were to become absorbed he would in his next attempt employ a steel pin! Later (September 1936) appeared Mercer's [22] article describing his method of operative treatment of spondylolisthesis by an osteotomy of the lumbosacral junction from an anterior intra-abdominal approach. He stated that it was his practice to remove some or all of the intervertebral disk and bony surface, which he replaced by a two piece bone graft obtained from the patient's ilium. The patient was operated on while lying in a posterior plaster of paris shell prepared beforehand so that he could not be hyperextended while being moved and the bone grafts thus permitted to fall out of place.

In attempts at curative treatment by the support of new bones and osteosynthesis, it must not be overlooked that the principal causes of

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20. Capener, N.: Spondylolisthesis, Brit. J. Surg. **19**:374 (Jan.) 1932.

21. Burns, B. H.: Two Cases of Spondylolisthesis, Proc. Roy. Soc. Med. **25**:571 (Feb.) 1932; Operation for Spondylolisthesis, Lancet **1**:1233 (June 10) 1933.

22. Mercer, W.: Spondylolisthesis, with Description of New Method of Operative Treatment and Notes of Ten Cases, Edinburgh M. J. **43**:545 (Sept.) 1936.

pain and acute displacement are at least three: (1) lifting heavy weights, (2) falling, especially on the buttocks, and (3) falls of heavy weights on the shoulders and back. The tilting of the sacrum may not be such an important factor in this mechanism because lordosis of the spine may not be present at the beginning of the act or trauma. In lifting a weight, for instance, a man starts with the hips flexed and the lumbar portion of the spine arched backward, but, as explained by Armitage Whitman, elevation of the load is carried out by use of the gluteus muscles. This action results in extension of the hips, during which the sacrum is actively tilted backward and forced against the laminas of the fifth lumbar vertebra. Lordosis is therefore absent at the start of the action but appears later, secondary to displacement at the lumbosacral joint. The upper surface of the sacrum is rotated into a nearly vertical position and carries with it the spinous process of the fifth lumbar vertebra. Capener stated the belief that this is the overlooked factor whereby the upper and posterior borders of the sacrum act as the apex of a wedge, which is driven upward and splits the fifth lumbar vertebra into two parts at the site of the congenital nonunion. Thus spondylolysis is initiated and spondylolisthesis or slipping follows.

On the basis of these findings a posterior bone graft or spinal fusion appears mechanically inefficient in attempts at cure. Even if the sacral surface, the split lumbar vertebra—posterior portion—and the lumbar spines and laminas above are locked together, it does not necessarily mean that the anterior part of the fifth lumbar vertebra (corpus and supporting facets) may not plunge farther forward and rotate down in front of the sacrum as time advances. An additional factor in favor of the anterior placing or wedging of the bone graft is found in the presence of spina bifida occulta in nearly 20 per cent of the cases, militating against a good sacral attachment of the posterior graft.[23] Nature apparently tries to limit the forward displacement of the fifth lumbar vertebra by building up a bony buttress along the anterior margin of the base of the sacrum. Thus is supplied an aid to the iliolumbar ligaments in stopping the rotation downward and obtaining a natural arrest of the slipping. Why not then implant the autogenous bone at a proper angle to penetrate the body of the fifth lumbar vertebra, traverse its intervertebral disk if necessary and engage well into the upper sacral segment? New fusion should follow to lock the whole bonily together. It appears that this method might suffice and that osteotomy with removal of the intervertebral disk, favored by Mercer, would be a little too extensive and possibly unneeded in the average case. Nailing with

23. Congdon, R. T.: Spondylolisthesis and Vertebral Anomalies in Skeletons of American Aborigines, with Clinical Notes on Spondylolisthesis, J. Bone & Joint Surg. **14**:511 (July) 1932. Kleinberg, S.: Traumatic Spondylolisthesis. Arch. Surg. **3**:102 (July) 1921.

a steel pin without performing osteotomy or freshening the surface of the bone would not positively insure bony fusion, although the pin might hold longer than an autogenous bony transplant. There is, however, by this method a smaller opening and less freshening of the bony surfaces to permit irritation, extravasation of blood and formation of new bone.

TECHNIC OF THE OPERATION

An attempt may be made by suspension traction in bed to overcome some of the displacement of the fifth lumbar vertebra, depending on the duration of the condition and the roentgenologic findings.

An abdominal incision, midline umbilicus to pubis, permits full exposure of the sacral promontory after the patient is tilted back and the intestines are packed away. The promontory is palpated, and the exact condition and extent of rotation of the fifth lumbar vertebra are determined in order to confirm the roentgenologic findings. If the bifurcation of the aorta is low, it may, along with the left common iliac vein, be gently held back by a padded retractor. The peritoneum over the fourth interspace down to the sacrum is incised just to the right of the midline, and an effort is made to avoid the midsacral nerve and artery and the ganglia of sympathetic nerves. If the artery bleeds, it must be tied. The amount of displacement and angulation having been decided, a chisel is used to make an entrance into the vertebral bony mass at or below the level of the fourth interspace. The angle required to penetrate the body of the fifth lumbar vertebra and to enter the sacrum must then be decided, and a large drill is inserted through the body of the fifth lumbar vertebra obliquely, nearly directly downward, as the patient lies supine. Its point can be felt passing through the lower or posterior border of the body of the fifth lumbar vertebra, to enter the intervertebral space and then pass on into the new resistance of the sacrum. The depth of the hole made by the drill and the length of graft required may be predetermined by measurement. A bony transplant from the tibia or any other source, of the same diameter as the hole, is then tamped gently into place; the subperitoneal tissue is approximated with interrupted catgut and the posterior peritoneum with a running stitch of catgut, and the abdomen is closed completely without drainage.

No plaster bed or splint seems necessary in after-treatment. A moderately firm mattress or fracture bed, which permits nursing care without flexion of the back, is used. Confinement in bed lasts eight weeks and is followed by ambulation and the use of a steel back brace until there is roentgenologic evidence of bony fusion.

REPORT OF A CASE

My investigation brings to light the first instance of anterior fusion of the bone, done by Jenkins, the second, by Burns, the third, by Mercer using Burns's method (his patient died two years later in childbirth) and the fourth and fifth, by Mercer using his own technic. In the fourth instance, the patient died on the eighth postoperative day, after passing blood in the stools; postmortem examination showed thrombosis of the superior mesenteric artery. The patient in the fifth instance was well one year after operation. The sixth instance was in a case of mine, in which the operation was performed without knowledge of any of the others except the first.

B. P., a man aged 48, was admitted to the Presbyterian Hospital at Chicago on April 26, 1937. In 1922, when he was working in the tallow and hide business, a wagon he was driving turned over, and he jumped to avoid injury. One foot was caught by the toe so that in jumping and falling he twisted his back. He had severe pain in the lumbosacral region but was able to get up, rehitch his team and get back to quarters. A disabling back ache continued for several days, followed by apparently complete recovery from all symptoms. About three weeks after the accident he had progressive lameness in the left leg and later, while plowing, would stumble and fall. The claudication in the left leg persisted,

Fig. 1.—*A*, a man with spondylolisthesis viewed from behind. The depression at the lumbosacral level and the hypertrophy of the spinal muscles can be seen. The deep crease around and above the iliac crests is characteristic. *B*, lateral view of the same patient. The thoracolumbar lordosis and the protuberant abdomen are apparent.

but he continued at work, though complaining of continual back ache, until eighteen months before his admission to the hospital, at which time his symptoms became so aggravated that he had to cease work. In the five months preceding his admission he had become nervously irritable, and had had a small urinary stream, and his visual acuity had diminished.

Since the onset of his trouble he had been examined by several physicians, including irregular practitioners, and been subjected to numerous blood tests, all of which gave normal findings. Repeated roentgenologic examinations had demonstrated a slipping forward of the body of the fifth lumbar vertebra. Eighteen months before admission he fell down some stairs, after which accident the symptoms in his back and leg had increased in severity. A stricture was present, following a specific urethritis contracted more than fourteen years before, for which he was treated for two years by urethral injections. Urethral dilatation with sounds had been performed for the preceding three years with considerable benefit. All his teeth were extracted three years previously; he had undergone no major surgical operations.

The examination on admission showed a rather slender white man, 48 years old, not acutely ill, complaining of back ache with claudication in the left leg. The general physical and laboratory examinations showed little abnormality; there

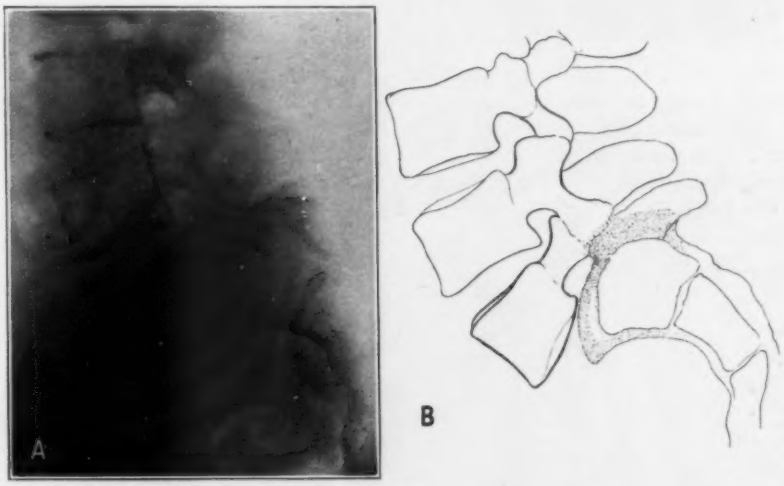

Fig. 2.—*A*, lateral view of the lumbosacral spine of the patient shown in fig. 1. The tipped axis of the sacrum and the projection forward of the body of the fifth lumbar vertebra with all the superimposed vertebral bodies are shown. The print does not show clearly the deficiency in the laminas. *B*, tracing of the roentgenogram. There is much new bone along the anterior and superior border of the base of the sacrum. The positions of the centrum and of the spine of the fifth lumbar vertebra are typical of spondylolisthesis.

were leukocytes in the urinary sediment, varying in amount on several occasions and accompanied by a trace of albumin when a high count was obtained. No casts were present in the urine. The patient's back was markedly lordotic, with a concavity at the lumbosacral junction, bounded on each side by outstanding and apparently hypertrophied spinal muscles. A finger placed in this cavity could palpate a bony floor, apparently part of the upper border of the sacrum. Extending from the depression was a bilateral transverse crease in the skin, extending as far as the posterior axillary line. The abdomen was protuberant but presented no hernias, no free fluid and no palpable masses. The prostate was moderately enlarged, smooth and firm and not tender. No arteriosclerosis was palpable, and

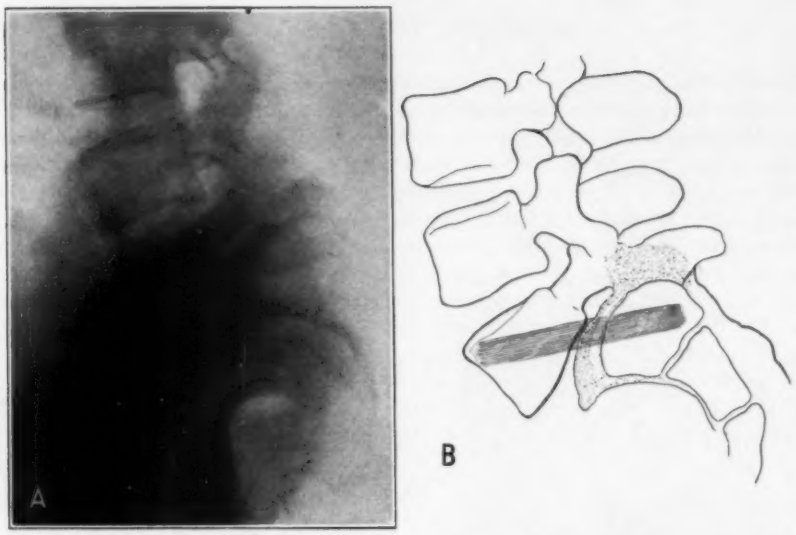

Fig. 3.—*A*, postoperative lateral view of the lumbosacral region. The transplanted bone penetrates through the corpus of the fifth lumbar vertebra, past the lumbosacral intervertebral space, on into the sacrum and nearly to the sacral canal. This transplant is sizable and should lead to bony fusion. *B*, tracing of the roentgenogram. No part of the transplant projects beyond the anterior margin of the body of the fifth lumbar vertebra.

Fig. 4.—Tracing of a roentgenogram showing an anteroposterior view of the transplanted bone postoperatively. The transplant (or Smith-Petersen nail if used) appears foreshortened on account of its tilted axis. By intention the transplant is placed slightly to the right of the middle line, as this insertion avoids the arch of the iliac veins and vena cava as well as the middle sacral structures.

all tendon reflexes were normal except the patellar, which were slightly exaggerated. The count showed: blood hemoglobin, 95 per cent; erythrocyte count, 4,900,000; leukocyte count, 9,000, and polymorphonuclears, 72 per cent. The blood pressure was 140 systolic and 80 diastolic. The roentgenologic findings indicated a marked forward displacement of the fifth lumbar body on the sacrum, producing a sharp S-shaped curve at the lumbosacral junction and a thickening of the anterior margin of the first sacral segment. It was believed that there was a separation of the isthmus on both sides of the neural arch of the fifth lumbar

Fig. 5.—Section through a human (normal) pelvis after the insertion of a bony transplant for illustration. When spondylolisthesis is present it is not so difficult to insert the transplant or a Smith-Petersen nail as it is in the normal bone. The overhang of the body of the fifth lumbar vertebra permits a more direct and less oblique angle of insertion and a deeper penetration into the first sacral body.

vertebra, but this condition was somewhat obscured by cloudiness and by a small amount of new bone which blocked the view. In the posteroanterior view the centrum of the fifth lumbar vertebra cast a semilunar shadow, seen through the body of the first sacral segment. There was little scoliosis.

One day after admission, the patient was placed on a modified Rogers bed with skin traction on both legs and a jury-mast on the head for countertraction.

The amount of traction and the angle of the bed, extending the spine, were increased frequently up to the patient's limit of tolerance, until there was at least 40 pounds' (18 Kg.) traction on the legs. There was no apparent change in the deformity of the back, and a second roentgenologic examination showed no reduction of the displaced vertebra after ten days' trial of this method. After this attempt at reduction the patient was released from hyperextension of the spine, with traction, and prepared for operation, which was performed on May 10. He was placed under anesthesia induced with ethylene and a small amount of ether, and a transplant of his own bone was removed by the motor saw set at a width of 5/12 inch (1 cm.) from the anterolateral surface of the right tibia, the wound being immediately closed and dressed.

The abdomen was then opened by a paramedian incision on the right, encircling the umbilicus and extending nearly to the pubis. Neither adhesions nor abnor-

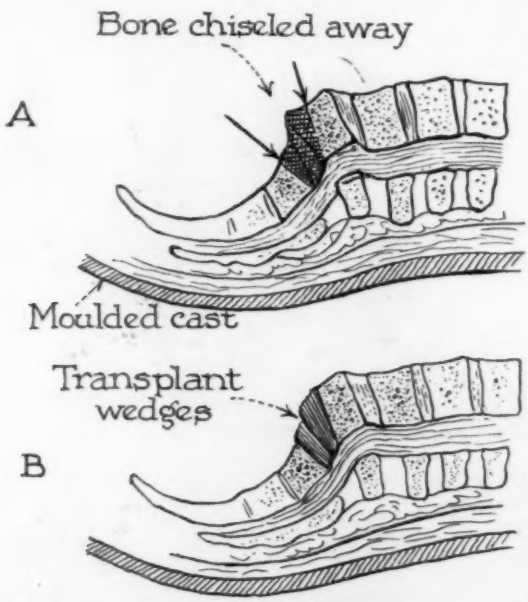

Fig. 6.—*A*, Mercer's operation, schematically drawn. The chisel cuts away the shaded area, removing the intervertebral disk and tissues with some bony surface. His description of the operation includes the fact that the patient lies on a previously prepared plaster of paris shell, so that no flexion or angulation of the spine is possible postoperatively. *B*, bone transplants wedged into the defect according to Mercer's description. He apparently intends transplants to hold by surface friction; hence the great care needed in handling the patient after the operation. Flexion at the lumbosacral junction might easily displace the wedges of transplanted bone.

malities presented themselves in the abdomen. The abdominal viscera were completely packed away from the sacral promontory by moist sponges. The patient's head was depressed about 20 degrees from the horizontal, and it was then possible to visualize and palpate the projecting body of the fifth lumbar vertebra where it overhung the upper sacral surface. A vertical incision was made through the peritoneum and the subperitoneal fat over the body of the

fifth lumbar vertebra and the fourth intervertebral space, slightly to the right of the middle sacral artery, which could be plainly seen. No special efforts were required to retract the aortic arch or left common iliac vein and inferior vena cava out of the field. (In some of the reported cases and in my study of the normal cadaver, it has been found necessary to apply a padded, flat retractor under the left common iliac vein or aortic bifurcation and also to tie an ascending vein which passes up the anterior surface near the middle of the sacrum to enter into either the left common iliac or the vena cava at the junction.)

The sympathetic nerve plexuses in this region were avoided by reflecting the peritoneum with its underlying fat and clinging closely to the bony surface with a small periosteotome. The anterior surface of the body of the fifth and the fourth interspace, easily recognizable, was adequately exposed, and a 5/12 inch (1 cm.) drill was then inserted at the upper border of the fifth lumbar body and directed downward into the first sacral segment. The change in the resistance to the drill as it passed through the lower border of the fifth lumbar body into the lumbosacral interspace, traversed it and entered into the bony tissue of the upper sacral surface could be plainly felt by my hands operating the instrument. When sufficient penetration was obtained, the drill was withdrawn, and the tibial transplant was found to fit snugly enough to require but a slight amount of tamping to engage in the opening made by the drill and be sunk to a level which would permit closure over it. The subperitoneal fat was closed with a few interrupted catgut sutures and the peritoneum over that with a running catgut stitch. There was no oozing. The abdomen was closed in layers, and the patient was carefully lifted from the table and placed in an ordinary hospital bed without flexion of the spine.

His recovery was almost uneventful. On the third postoperative day his temperature touched 100.2 F. Both abdominal and tibial wounds healed kindly. On the second day he vomited a few times, never more than 75 cc. of material. He had trouble in urination, and a self-retaining catheter was with some difficulty inserted past his stricture. This was left in place two days and then withdrawn. On May 16 and 17 he had an involuntary urination, and on the night of May 16, harboring hallucinations, he got up out of bed! On May 25 he was placed on a Goldthwaite frame and a circular torso plaster of paris dressing was applied, holding the spine in slight extension. On June 17 he was discharged, wearing this plaster corset. He made no complaint of pain in the back; his old distress was gone; he had no difficulty in urination or control of his bowels, and the wound was healed. He was fitted with a side iron to protect the right tibia, from which transplant had been removed, against injury. He left using crutches on account of the heavy plaster and long confinement in bed with subsequent loss of muscular strength. On August 17 the plaster corset was removed and a roentgenogram of the spine made. This showed the transplant in the same position in which it was placed. There was an area of lighter density about it, probably representing extravasated blood and some absorption of bone (fig. 3). The patient was reexamined on September 6. He was able to walk without support and had absolutely no pain in his back. There was still a little of the old dragging in the leg and tire in the upper part of the thighs after he had walked two blocks.

CARCINOMA OF THE BREAST

REVIEW OF FOUR HUNDRED AND THIRTY-NINE CASES

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ETIOLOGY AND SUSCEPTIBILITY

The cause of mammary cancer, in common with that of other types of malignant tumor, is not definitely known. Even though many facts have been learned, mammary cancer appears to have reached a point beyond which effective prevention seems well nigh impossible.

Chronic mastitis is believed by most authorities to be the principal predisposing condition, but cancer so often occurs without pronounced chronic mastitis or in a very early stage of mastitis that this theory in itself is inadequate to explain the frequent incidence. All will agree, however, that mammary cancer must be preceded by involutional or inflammatory changes. The sweat glands of the breast are frequently the site of origin, and the causation of lesions so originating is probably somewhat different from that of the common duct cancer. Cancer originating in the sweat glands usually appears near the skin and in the axilla and is particularly prevalent among persons with the seborrheic diathesis.

Many observers have pointed out the prominence of stagnation of secretion in the cancerous breast, and Keynes (quoted by Ewing [1]) has emphasized the part played by stagnation in chronic mastitis. Cheatle (quoted by the same author) also has emphasized the importance of chronic irritation by retained secretion in the development of cysts and periductal fibrosis complicating chronic mastitis.

The entire question has been greatly illuminated by Bagg,[2] who in a race of mice known to have a low incidence of cancer succeeded in producing mammary carcinoma in 85 per cent of cases merely by with-

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From the Guthrie Clinic.

Thesis submitted to the Faculty of Surgery of the Graduate School of Medicine of the University of Pennsylvania in partial fulfilment of the requirements for the degree of Master of Medical Science (M.Sc. [Med.]) for Graduate Work in Surgery.

1. Ewing, J.: The Prevention of Cancer, Surg., Gynec. & Obst. **44**:165, 1927.

2. Bagg, H. J.: The Functional Activity of the Breast in Relation to Mammary Carcinoma in Mice, Proc. Soc. Exper. Biol. & Med. **22**:419, 1925.

drawal of the suckling young immediately after birth, thus allowing stagnation to occur in the breasts of the female mouse. Adair [3] reported that in only 8 per cent of 200 cases of mammary cancer was there a history of normal lactation. In following his work further he found that a great many of the patients showed large amounts of inspissated or puriform material, which could be withdrawn by means of the breast pump. A similar phenomenon was noted with chronic mastitis, and after removal of the retained material the indurated nodules and cysts often completely disappeared.

There exist, then, clinical, anatomic and experimental data indicating that stagnation of secretions is a prime factor in the causation of chronic mastitis and of mammary cancer, and a basis is thus laid for the hygiene of the breast and for the prevention of mammary cancer.

One of the few known facts about cancer is its relation to age. In women the senile changes taking place during the fourth and fifth decades are definite factors in bringing about cellular changes which invite cancer. W. J. Mayo [4] made the statement that cancer does not appear in sound tissue and that the one provocative agent which remains unchallenged is chronic irritation. In all lands and among all peoples we see this one causative influence in the ascendant. Carcinoma of the scalp is particularly common among those Chinese who shave their heads with a dull and rough-edged razor, but it does not appear in those who do not follow this custom. The eating of hot rice by the men, who eat at the first table, is frequently the forerunner of carcinoma of the pharynx and of the esophagus. The condition does not appear in the women, who eat at the second table, when the rice is cold. In Australia, the sharp-edged sand blown by hot winds in the desert section of the country so frequently produces cancer of the face that such cancer is called the Australian disease. In certain parts of India and the Phillipines, where betel nut and lime are still chewed, cancer of the buccal mucous membranes is common. Many instances of chronic inflammation produced by tobacco, by hot pipe stems and by ragged stumps of teeth can be cited, showing such inflammation to be definite predisposing factor in the production of cancer. In countries where the breasts are allowed to be exposed, that is, are not compressed or irritated by covering, carcinoma is rare. Cancer of the breast occurs chiefly among civilized women. In the mountain regions of Kashmir, India, where the people carry braziers filled with hot coals strapped on the lower part of the abdomen, cancer just above the pubis is common. A possible explanation is that when the tissues have been subjected to a

3. Adair, F. E., and Bagg, H. J.: Breast Stasis as the Cause of Mammary Cancer, Internat. Clin. **4**:19, 1925.

4. Mayo, W. J.: Susceptibility to Cancer, Ann. Surg. **93**:16, 1931.

long-continued insult the reparative processes are exhausted; instead of healthy cells, less mature cells are thrown into the breach of continuity; finally, embryonic cells replace the normal cellular structure.

Newer revelations seems to indicate that cancer may be the result of agencies acting from within the body (as well as from without) due to biochemical dysfunction affecting the life history of embryonic cells. Whatever the nature of the agencies producing malignant tumors, it is evident that they are inseparable constituents of the cell, as metastasis takes place only by the transplantation of the malignant cell itself.

In the final analysis, cancer is a recessive condition. Roughly, about 10 per cent of all persons have cancer in some form, while about 90 per cent escape. It is not logical to assume that persons in the latter group do not come in contact with some or all of the causative factors. It would seem that susceptibility to the causes of malignant degeneration, whatever they may be, is subject to individual variation and that increasing age tends to lessen the reparative powers and to decrease immunity. The work of Maud Slye in breeding strains of mice, which is familiar to all physicians, bears out this contention and shows very well the importance of heredity in resistance or susceptibility to cancer.

AGE AND SEX INCIDENCE

Carcinoma is especially prevalent in the fourth and fifth decades, more than 50 per cent of all carcinomas being discovered during these years. Stubenbord [5] showed the following data:

Age at Onset, Years	Percentage
20-30	3
30-40	18
40-50	30
50-60	30
60-70	19

In Schreiner and Stenstrom's [6] series of 563 cases, 58 per cent of the lesions occurred between the ages of 40 and 60, while the statistics of Moschcowitz and Colp [7] (218 cases) and those of Judd [8] (651 cases)

5. Stubenbord, J. G.: Cancer of the Breast, Surg., Gynec. & Obst. **52**:1001, 1931.

6. Schreiner, B. F., and Stenstrom, A. T.: End Results in Five Hundred and Sixty-Three Cases of Breast Cancer, Surg., Gynec. & Obst. **44**:609, 1927.

7. Moschcowitz, A. V., and Colp, R.: Late Results After Amputation of the Breast for Cancer, Ann. Surg. **84**:177, 1926.

8. Judd, E. S., and Sistrunk, W. E.: End Results in Operation for Cancer of the Breast, Surg., Gynec. & Obst. **18**:290, 1914.

showed the occurrence of 51 and 43 per cent, respectively, between these ages.

Table 1 shows the age incidence of cancer of the breast in various series.

Although various methods of defining the age decades are used, such as from 21 to 30 or from 20 to 29, and although in some series the age at operation rather than the age at onset is used, the data given in the table are accurate for all practical purposes. It is plainly seen that the maximum incidence of cancer of the breast occurs between the ages of 40 and 50 years. In this connection, it is said that in Switzerland the peak is reached from two to three years later than in the neighboring German-speaking countries.

Carcinoma occurring in persons under the age of 20 is rare and usually is reported in the literature. There was only 1 such lesion in

TABLE 1.—*Age Incidence of Mammary Cancer*

Author	No. of Series	Under 20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Schreiner and Stenstrom [6]..	563	0	6	49	150	192	112	50	13
Pfahler, G. E., and Widmann, P. P.: Am. J. Roentgenol. **14**: 550, 1925	801	2	20	79	285	243	122	48	2
Harrington [9].....	2,083	1	31	304	732	611	305	94	5
Guthrie [10].....	439	0	7	23	99	86	68	30	2

Harrington's [9] series and none in the Guthrie Clinic [10] series. In this series, 4 carcinomas, or a little less than 1 per cent, occurred in male patients. Three of these male patients are dead of cancer after two years, and 1 is alive, with recurring cancer.

Winslow [11] had 3 male patients in 102 cases. He also reported a case in which a fibroadenoma occurred in the breast of a 17 year old girl. This tumor was malignant at the time of its removal.

As far as racial incidence is concerned, it is interesting to note that, according to Stubenbord,[5] cancer of the breast occurs infrequently in members of the Negro race. He reported only 2 instances in 108 cases in which the patients were of fourteen different nationalities. Because of the diffuse admixture of races in the Guthrie Clinic series it was impossible to arrive at any conclusions concerning racial distribution.

9. Harrington, S. W.: Carcinoma of the Breast: Surgical Treatment and Results, J. A. M. A. **92**:208 (Jan. 19) 1929.

10. Guthrie, D.: The Rodman Operation for Breast Cancer, J. A. M. A. **63**:1256 (Oct. 10) 1914.

11. Winslow, R.: An Analysis of One Hundred and Two Cases of Tumors of the Breast, Ann. Surg. **74**:341, 1924.

RELATION OF CARCINOMA TO CHRONIC CYSTIC MASTITIS

Much has been written in regard to chronic cystic mastitis and its relationship to cancer of the breast. Bloodgood [12] repeatedly has presented careful histologic studies of the various benign tumors of the breast, with comments on their etiologic relationship to cancer. He concluded that cancer does not often develop in a breast presenting a single large cyst but is frequently associated with the diffuse type of the disease. This opinion seems to have been shared by most writers.

The role of stasis and faulty drainage of the breast has received much attention in this respect. Adair and Bagg,[8] whose work with mice has been referred to, concluded that stasis is significant in giving rise to proliferative changes and subsequently to cancer.

Campbell,[13] in a complete review and analysis of the literature, stated that the histologic evidence in favor of the theory that cystic disease is precancerous may be summed up as follows:

1. Cystic disease is frequently found in association with frank carcinoma.

2. Various gradations of epithelial proliferation may exist to give the impression that cystic disease represents a progressive evolution of epithelial hyperplasia eventuating in carcinoma.

3. The examination of tissue removed from breasts containing cystic disease frequently reveals histologic pictures which may be interpreted as representing early cancer.

He went on to say, however, that cystic disease is not a precancerous lesion and that malignant changes are no more likely to develop in a breast showing the disease than in one which is entirely normal. He presented the following review of Bloodgood's work in this connection:

An entirely new approach to the problem is offered by Bloodgood. Convinced that most cases of cystic disease never become malignant and that many needless amputations were being done, he practiced limited operations and followed his patients for years to determine the incidence of carcinoma. Thus he obtained a correlation between the various histologic pictures and the clinical course of the disease.

It is of interest that in 1904 Bloodgood, basing his opinion on microscopic criteria only, had concluded that malignant epithelial change occurred in 10 per cent of all cases of cystic disease. In 1906 he wrote that adenocarcinoma was already present in over 50 per cent of patients with the adenocystic variety of the disease whom he had examined.

In 1921, having changed his opinion, he reported his experience with 350 cases of cystic disease, in 128 of which the treatment had been local excision only. A follow-up showed that carcinoma had developed in 3 of these cases, an incidence

12. Bloodgood, J. C.: Borderline Breast Tumors, J. A. M. A. **104**:439 (Feb. 9) 1935.

13. Campbell, O. J.: Relationship Between Cystic Disease of the Breast and Carcinoma, Arch. Surg. **28**:1001 (June) 1934.

of about 2 per cent. He concluded that with the exception of nonencapsulated cystadenoma, or, as it is here termed adenocystic disease grade II, cystic disease is not a precancerous lesion and cancer is no more likely to develop in a breast so involved than in a normal one.

In 1929 he amended this impression by including diffuse nonencapsulated cystadenoma among the benign lesions. He had recognized this variety of the disease in over 100 patients and treated them without operation. Malignant tumors did not develop in any of them. In the same year he reported his experience with over 300 cases in which blue domed cyst was treated by local excision. A follow-up over a period of years showed no greater incidence of carcinoma than in women with normal breasts.

Reviewing his locally removed "border-line" tumors in 1931, he found that all of these patients, over whose diagnosis pathologists had disagreed fifteen years before, were living and well or had died of other causes without having shown evidence of cancer.

Bloodgood has therefore concluded from his years of study, combining and correlating microscopic pictures with the clinical course of the disease, that cystic disease per se is not a precancerous lesion.

Campbell [13] did not advise the amputation of breasts with cystic disease because of the risk of malignant degeneration. He stated that the conservative policy toward cystic disease of the breast "is based on the fear that carcinoma may be present and unsuspected at the time of the examination rather than on the fear that a malignant condition will subsequently develop." He concluded that cystic disease calls for an exploratory incision and frequently for a limited operation, but only rarely for amputation.

Campbell [13] also stated that all single solid tumors in women over the age of 25 should be removed for diagnosis. Gross diagnosis is possible in about 80 to 90 per cent of cases, but in a certain number microscopic examination of a frozen section must be resorted to. For single small localized areas biopsy is the safest method. In the presence of multiple tumors in one or both breasts, which is in itself strong evidence of the benignity of the process, it is advisable to remove one or two of the most questionable ones for examination, because if carcinoma is developing in a breast containing benign tumors it can be recognized clinically only after the characteristic late signs of malignancy have appeared.

Cysts large enough to be recognized clinically are usually benign. However, a malignant condition may be present in the wall of a cyst,[13] and for this reason single cysts should be excised. The breast with the diffuse form of the disease, the shotty or nodular breast, need not be operated on but should be closely observed. When one area in a diffuse process stands out from the rest or seems to be developing at a more rapid rate it should be excised and examined. The remainder of the breast is of no aid in arriving at a diagnosis.

Bleeding from the nipple demands excision of the localized area of breast tissue for examination. Over 50 per cent of lesions in such cases will be found benign.[13] If the sources are multiple, amputation should be resorted to, because only serial section can rule out a malignant lesion, and obviously this is not practical. If a malignant lesion is found, radical operation, of course, is to be performed. The same holds true when the pathologists is in doubt as to the true histologic picture.

MARITAL INCIDENCE; PREGNANCY AND LACTATION

Stubenbord [5] found that 81 per cent of carcinomas of the breast occur in married women and 10 per cent in unmarried women, while Schreiner and Stenstrom [6] reported 85 per cent in married women and 15 per cent in single women. Roughly, 83 per cent of patients in the series here reported were married and 17 per cent were unmarried. Possibly lactation, pregnancy and trauma of feeding play a part in the production of malignant tumors, although Burton J. Lee [14] concluded otherwise. Physicians have been taught that cancer of the breast occurs more frequently in women who have had previous lactation, but Lee [14] believed this to be an incorrect assumption and said that, although the larger number of patients will be found to have had previous lactation, the percentage of this group in the total population of women over 25 years of age is probably much higher than that of women who have never lactated. No absolute proof of a higher incidence of mammary cancer in the latter group has been found.

In 315 cases in which data on the marital incidence were available, 28.2 per cent of the patients had never been pregnant, and of the 71.8 per cent that had been pregnant 90.7 per cent had breast-fed their children. The average number of children in 396 pregnancies was 1.8. The average age at onset of symptoms when the patient had breast fed the children was 45.4 years, as contrasted with 44.1 years when the children had been bottle fed. The average age at onset of symptoms when the patient had never been pregnant was 46.2 years.

These figures showing the average age of incidence are of some interest. They indicate that carcinoma develops somewhat earlier in the breast which has not met the physiologic demands incident to pregnancy and appears latest in those which did not suffer the physiologic changes of pregnancy and the possible trauma incident to breast feeding. In the same group of cases only 1 carcinoma arose within three years of pregnancy; the patient was a 34 year old woman who first noticed the mass in the breast twenty-eight months after nursing her first child. She

14. Lee, B. J.: End Results in the Treatment of Cancer of the Breast by Radical Surgery Combined with Preoperative and Postoperative Irradiation, Tr. South. S. A. **45**:201, 1933.

had had lumps in the breast before, but they had disappeared previous to her pregnancy.

Bloodgood[15] discussed the microscopic picture of encapsulated tumors removed from the breast during pregnancy or lactation, and in no instance was he able to find in these adenomas anything that resembled the microscopic picture of cancer.

GROSS PATHOLOGIC DIAGNOSIS

The gross diagnosis of mammary cancer is of increasing importance at the present time, chiefly because of the fact that patients are becoming educated to the significance of any tumor in the breast and are, therefore, presenting themselves earlier for medical examination. Cancer can be cured, but only as a result of early diagnosis and early appropriate treatment. Concomitantly, an increasing number of borderline cases is observed, in which the clinical diagnosis is doubtful. Frequently there is no question as to the diagnosis of mammary cancer immediately before an operation, because there are, unfortunately, many patients who have been suffering from cancer for months or years and have sought the advice of a physician only at the repeated urging of relatives or because that all-too-late danger signal, pain, has appeared. In such patients, with a large, hard, possibly ulcerated mass with extensive metastases to the axilla, the neck and the chest, there is little difficulty in diagnosis from a clinical point of view. Operative or postoperative pathologic diagnosis is of little value except in determining the degree of malignancy and the probable duration of life.

The diagnosis of early mammary cancer presents difficulties, yet the diagnosis must be made if the patient is to be cured. The surgeon and the pathologist alike must be familiar with the gross appearance of malignant tumors in order that appropirate treatment may be afforded the patient. Whether or not the services of a pathologist are available at the time of the operation, the surgeon must be competent to recognize carcinoma when it is present. The operative procedure to be advised depends on his accurate observation. Such accuracy is obtained only by careful study of the gross specimen and by correlation of its evidence with the evidence offered by the frozen section. By the use of this method it will be possible in the vast majority of cases to make an accurate diagnosis by gross examination alone.

It is the accepted policy of most surgeons today to advise the removal of any questionable lump in the breast and to subject it to microscopic examination. However, many patients are advised to wait until the mass makes its presence known by pain or by some other symptom. Carcinoma in the early stages is painless, and by the time it manifests

15. Bloodgood, J. C.: Biopsy in Breast Lesions, Ann. Surg. **102**:239, 1935.

itself to the patient it is usually too late to do anything except provide palliative treatment. It should always be advised that if a nodule removed proves to be malignant radical amputation is the action to be followed. If facilities are not available for immediate microscopic examination and the tumor is believed clinically to be malignant, a radical amputation should be done and a pathologic report studied later. In a great majority of cases "a single, hard nodule, with restricted mobility in an otherwise normal breast, is usually cancer." Likewise "every single, solid painless lump in the breast at any age should be considered cancer until ruled out by microscopic section." There may be multiple carcinomatous nodules in the breast, because it is not uncommon for cancer to arise from cysts or in chronic mastitis. Palpation is a valuable procedure and is best done with the flat of the hand against the chest wall. The patient should be examined in the supine and sitting positions with the arms extended above the head. The common fibroadenoma is frequently but not always single and is rarely fixed, being freely movable in the breast tissue. A malignant nodule, on the other hand, is more or less firmly fixed to the skin, to the fat or to the wall of the chest, frequently with dimpling and retraction of the nipple. There are occasional exceptions, in which a malignant tumor may be freely movable; this happens when carcinoma is confined to a cystic capsule and has not yet penetrated to the surrounding tissue. Also, in occasional cases fixation to the skin, with dimpling and restricted mobility, is associated with the inflammatory reaction of a benign tumor.

The consistency of the more common tumors is of some aid in arriving at a diagnosis. Carcinoma has a hardness peculiar to itself, resembling the hardness of cartilage, and is almost angular at times. Adenoma is usually softer than carcinoma and even when hard feels more like a hard rubber ball, there being a sense of slight compression. Occasionally a cyst under great tension feels solid; this may confuse the diagnostician. An occasional carcinoma (particularly if it arises from a cyst) may feel moderately soft and if associated with a residual cyst formation will escape notice. Even extensive involvement of the breast by the organized tissue of chronic mastitis does not give the same impression of hardness as does cancer. The tissue of mastitis is more resilient and has a rubbery toughness, making it somewhat difficult to cut, but it never has the scarlike appearance or the cartilage-like texture of carcinoma.

The color and the transparency of a mammary tumor are of some value in showing the type of lesion present. Valuable information can be gained by looking at the cut surface; carcinoma may show yellowish or white streaks or points. These vary in size and number and represent fine ducts filled with proliferated cells undergoing fatty degeneration.

The points are cross sections, and the streaks are ducts cut longitudinally. Diffuse carcinoma in which there is no definite tumor may give trouble, but the points usually can be found. Many sections may be necessary.

Gelatinous or mucoid carcinoma may not show the opaque structure or the points, but thin translucent gelatinous material may infiltrate the breast. Traumatic fat necrosis (clinically much like carcinoma, and a form of lesion which will be mentioned later) fails to show these features in the gross. Of course, hemorrhage, infection or extensive necrosis will complicate the picture.

In a large tumor which has originated in a cyst and has filled it and become solid, the entire cut surface may be pale yellow or orange, with a grayish granular surface, from which cellular material (sometimes called "cancer milk") may be scraped with a knife. The benign adenoma has a white translucent surface, and no cellular debris can be scraped off. The dense tissue of mastitis is white and waxy, has no yellowish points or streaks and is acellular. Scraping it produces nothing. There are in addition widely scattered cysts of various sizes throughout the tissue.

In some patients the breast is the site of long-standing mastitis; the glandular tissue feels like a mass of knotty cords without an isolated tumor mass. Section in these cases frequently presents difficulty in reaching a dilated duct filled with a putty-like greenish to gray material. The tissue is vascular and edematous, and the gross appearance is alarming. The breast is diseased, but the malignant condition is frequently limited to the ducts, and infiltration is lacking. Microscopic examination is necessary. The condition is considered precancerous, and a simple rather than a radical operation is the rule. If the clinical evidence of a malignant condition is not conclusive, if the tumor is thought to be benign or if the diagnosis depends on microscopic examination of the tumor the whole tumor and not a piece should be removed, because the gross picture is helpful, and dissemination must be prevented.

CLINICAL DIAGNOSIS

The diagnosis of tumor of the breast is becoming increasingly difficult, because patients are coming to the physician earlier than ever before, showing lesions so small that signs of malignancy have not yet developed. This is especially true of women between the ages of 35 and 50. During these years cancer of the breast in the early stages is commonly confused with fibroadenoma, cyst, mastitis or fat necrosis, and each of these must be considered and ruled out. In general, there have been no new data on symptoms of cancer of the breast. The average preoperative duration of symptoms gives some indication of the

rate of growth and the degree of malignancy. Malignant tumors of the breast may be divided into two classifications: sarcoma and carcinoma. The diagnosis of the former is usually simple when the two main types are considered. The first of these is true sarcoma, which results from a preexisting fibroadenoma. There is usually a history of a tumor preexisting for many years, which suddenly begins to grow rapidly. The tumor assumes large proportions, invades the skin and proceeds to central necrosis. Softening and ulceration characterize a still later stage. The salient feature is a tumor of long standing which suddenly exhibits rapid growth and then breakdown. Neurogenic sarcoma is the second type and is probably equally common. This is not a true tumor of breast tissue but has its origin in the nerve sheath. It is round, firm and noninfiltrating. The treatment is wide mastectomy.

To treat adequately of the diagnosis of the second class of malignant tumors of the breast, carcinoma, one must distinguish the different types, because each has its own clinical characteristics and life history, and each has a different prognosis. The first, scirrhous carcinoma, or fibrocarcinoma, is a stony hard, irregular nodule, frequently attached to the skin and causing dimpling, retraction of the nipple and deformity of the breast. The tumor is slow growing and slow to metastasize, and because of these facts radical amputation offers a high percentage of cures.

The adenocarcinoma found in the breast is of a higher grade of malignancy than scirrhous carcinoma. The lesion is localized, but it does not have the drawn, scarlike appearance of the scirrhous cancer. Later in its development it breaks down and ulcerates. Metastases are late, but when they do occur they represent a serious advance in the progress of the disease. Radical surgical treatment produces good results when the growth is confined to the breast.

Duct carcinoma, or comedo carcinoma, represents a third type, which invades the entire breast but remains confined there until it is ready to permeate the confining tissues. Frequently there is only slight change in the contour of the breast, or none at all, and the growth may thus be overlooked. Retraction of the nipple, adherence to the skin and the typical pigskin appearance are later features of the picture. Here the prognosis is more serious than for the two preceding types of cancer, and wide excision of skin should be practiced.

Sweat gland carcinoma has as its characteristic feature its eccentric position in the periphery of the breast, usually in the mammary fold. Histologically it is a variety of adenocarcinoma and is easily diagnosed under the microscope because its cells take only the eosin stain. The lesion appears to be attached to the skin, moving with it, and is not so firmly fixed to the deeper tissues as is the adenocarcinoma. The axil-

lary glands are not involved so early in the course of the disease as in other types of carcinoma of the breast. The treatment is the same as that for adenocarcinoma.

Papillary cystadenocarcinoma is a type of malignant tumor which begins in one of the terminal ducts as a benign papilloma, most commonly situated in the ampulla, at the edge of the areola. It may remain benign for many years, but it continues to grow and later infiltrates the basement membrane and invades the surrounding tissues, becoming a true carcinoma. This variety is frequently responsible for a serosanguineous discharge from the nipple often lasting for years. The neoplasm is of a comparatively low grade of malignancy, but, like most mammary carcinomas, it offers a bad prognosis once the axilla becomes involved.

Gelatinous carcinoma is of low grade and is easily cured by radical excision, but if recurrence takes place the prognosis is bad because of the insistence of the growth. It is radioresistant, and the best hope of cure lies in radical and early excision.

The anaplastic type of carcinoma, the next under consideration, is a small growth, fairly hard, frequently mistaken for fibroadenoma and consequently many times wrongly diagnosed. The tumor is composed mostly of loose, rapidly growing, highly malignant cancer cells in a small amount of fibrous stroma. Metastases to bone are early and common even though the tumor is small in size. It is highly radiosensitive and should not be operated on until after a course of irradiation has been given. However, because of the difficulty in making an early and positive diagnosis, the treatment is usually not specific, and the mortality is high. Irradiation of both primary and secondary growths is of first consideration in the treatment, and excision should be done whenever possible.

Inflammatory carcinoma has a characteristic appearance. The involved skin of the breast has a sharply defined edge due to the invasion of the dermal lymph spaces by carcinoma cells. The picture resembles that of erysipelas. The lesion spreads rapidly through the skin. Irradiation is the treatment of choice; operation should not be attempted. The prognosis is essentially bad.

DIFFERENTIAL DIAGNOSIS

The diagnosis of fibroadenoma usually is not difficult. This is a round, smooth, firm tumor, not stony hard as is carcinoma. It is freely movable and has no cutaneous attachment. It is most frequently found in women under the age of 40, but even though the clinician feels strongly that the lesion is a benign one the safest procedure is to advise its removal and a detailed examination.

Cysts of the breast, unless they are of noticeable size, are difficult to diagnose. The small ones are tense and hard and may early be confused with fibroadenoma. They are not infrequently somewhat inflamed and hence attach themselves to the skin, simulating the clinical picture of a malignant tumor. If the presence of a cyst is strongly suspected, an aspiration needle may be introduced. This will clarify the diagnosis. The method of transillumination suggested by Cutler [16] has been used in this clinic, with a certain degree of diagnostic accuracy.

The diagnosis of mastitis when the condition is localized is never certain. The disease occurs in the cancer-bearing age and is not so frequent after the age of 55. The lesion is firm and irregular, with round nodules of varying size over its surface. It lacks the characteristic feeling of infiltration found in carcinoma; however, it is not freely movable with the breast tissue. It does not become fixed to the chest wall. If the lesion is multiple the diagnosis is much simpler. Again, the affected parts should be removed and subjected to detailed examination to determine the diagnosis and to rule out the presence of a malignant tumor in an early stage.

Mastitis should be divided into four types to facilitate diagnosis:

1. Cystic mastitis and fibrous mastitis are readily diagnosed. It is commonly found that the masses in the breast are rounded, irregular and indefinite. The lesions are firm and multiple. Pain at the time of the menstrual period or immediately before it is a common complaint.

2. Tuberculosis of the breast (Lee and Floyd [17]) was not a proved clinical entity until 1881, when Dubar proved microscopically the presence of tuberculosis in breast tissue. It is not a common lesion and, according to Barker, occurs once to each 50 occurrences of mammary carcinoma. Only about 4 per cent of patients in whom this condition occurs are men. Like carcinoma, it usually occurs during the reproductive years; however, carcinoma tends to appear oftenest in the latter years of this period. Fifty-eight per cent of carcinomas in the cases reported by Lee and Lloyd [17] were primary, no other focus being found.

The earliest symptom in 75 per cent of cases is a painless lump in the breast. A small percentage of patients have pain, and the rest show such symptoms as discharge from the nipple and sinus formation. The condition may resemble a malignant lesion, in that there may be retraction of the nipple and pigskin appearance of the surrounding skin. The mass may feel irregular, fixed and indurated and may show abscess formation. If the last-mentioned symptom is present together with

16. Cutler, M.: Benign Lesions of the Female Breast Simulating Cancer, J. A. M. A. **101**:1217 (Oct. 14) 1933.

17. Lee, W. E., and Floyd, W. R.: Tuberculosis of the Breast, Ann. Surg. **99**:753, 1934.

sinus formation, tuberculosis is to be strongly suspected. A serosanguineous discharge is an important confirmatory finding. There is involvement of the lymph glands in over 50 per cent of cases. Carcinoma with sinus formation may closely resemble tuberculosis, but this stage of carcinoma is becoming rare as the work of public education goes on. In many instances absolute diagnosis cannot be made in the gross and resort must be had to microscopic examination of the tissue.

3. Syphilitic mastitis, according to Thomas,[18] occurs most commonly in women, only 25 per cent of patients in reported cases being men. Bilateral involvement is common. The tumors may be either single or multiple and may vary in size from a barely palpable nodule to a mass some 3 to 4 inches (7.6 to 10.1 cm.) in diameter. The tumors are hard, well circumscribed and movable. They may be subcutaneous or embedded within the parenchyma. The axillary glands are seldom involved. The tumors if untreated progress to ulceration and sloughing, with the punched-out appearance typical of ulcerating gummas. Pain is not a common finding and when present is not so severe as that of carcinoma. Carcinoma appears later in life than does gumma. A positive serologic reaction is of prime importance in the diagnosis.

4. Plasma cell mastitis, the last of the four types of mastitis, is a curious unexplained inflammatory process which tends to spontaneous regression and disappearance. It shows a rather characteristic history and has the general clinical signs of a malignant lesion. Usually, during the course of lactation the breast becomes acutely inflamed and presents a clinical picture simulating that of inflammatory carcinoma. A mass develops suddenly in the breast, and there is tenderness and redness of the skin. The entire breast becomes swollen, the axillary glands are enlarged and tender and there is occasionally a discharge from the nipple. The mass subsides partially but not completely, leaving a hard lump. The most important point of difference from inflammatory carcinoma is the absence of dermal thickening, representing invasion of the skin by malignant cells. There is attachment of the nipple and occasionally an orange-skin appearance to the epidermis. The acute symptoms soon subside, and the residual mass takes on many of the characteristics of a malignant tumor. In addition to these symptoms of cancer the mass itself shows hardness and a feeling of infiltration. The mass, however, very slowly decreases in size, and this is the crucial sign which enables it to be differentiated from carcinoma in this stage of the disease. Other important diagnostic aids in the differentiation of plasma cell mastitis from carcinoma are the acute onset of the disease and its subsequent clinical course.

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18. Thompson, L.: Gumma of the Breast, J. A. M. A. **74**:791 (March 20) 1920.

Traumatic fat necrosis (described by Burton J. Lee [14]) is most common during the fourth and fifth decades, according to Cutler,[16] and can easily be mistaken for a malignant tumor both in its appearance and in its clinical characteristics. Trauma is an essential etiologic factor, and although it is found with a history of carcinoma it occurs much more frequently in cases of fat necrosis. Hemorrhage into the fatty tissue, with resultant fibrosis, seems to be the pathologic process. Fat necrosis resembles carcinoma in many respects. At first, there is a rapid increase in the size of the mass, due to proliferation of connective tissue in response to the chronic inflammatory process. Proliferation may not be apparent until several weeks or months after the injury.

Adherence to the skin is a common feature, and retraction of the nipple may be present, leading one immediately to suspect malignant tumor. The consistency of fat necrosis is like that of carcinoma, and there may be fixation to the deeper underlying structures, although in most cases the tumor of fat necrosis is fairly well circumscribed and can be moved around in the breast tissue with greater ease than can a malignant tumor.

Radical excision, of course, is not necessary, fat necrosis being classed with the benign lesions of the breast.[19]

Paget's disease of the nipple is a condition which is said to be most common in women between the ages of 35 and 50. It first manifests itself as intractable eczema of the nipple. The area around the nipple is usually bright red and inflamed, with a finely granular surface. The surface may be moist and weeping, with a grayish exudate, or dry and scaly. The border is circinate and slightly raised. Within two years usually but occasionally not for as long as ten years, carcinoma appears in the breast. The debate as to which condition is primary seems still to be unsettled. There are those who follow Handley and believe that Paget's disease of the breast is essentially a malignant condition and that the eczema is the result of the carcinoma, while there are many others who follow Paget in believing that the disease begins in the skin, carcinoma of the breast being a secondary development.

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19. In this connection, an interesting case has been recorded at the Guthrie Clinic since this paper was written. A woman, aged 60, was admitted with a history of trauma to the periphery of the upper middle quadrant of the right breast six weeks previous to admission. The injury was followed by painful swelling, which gradually subsided to a tender, ill defined mass. The mass was removed by simple amputation, and microscopic examination showed adenocarcinoma in the wall of a cyst, approximately 1 cm. in diameter, with a firm dry, whitish center. There were several areas of pigmentation, and evidence of old hemorrhage was present with the necrotic fat. There was no axillary involvement. Radical amputation was then done.

In any event, the recognition of Paget's disease calls for radical surgical intervention.

GROWTH AND SPREAD

Carcinomas of the breast showing involvement of the lymph nodes decidedly outnumber those that have no such involvement. In the cases reported by Moschcowitz and Colp,[7] metastases to lymph nodes were present in 56 per cent, absent in 35 per cent and not mentioned in the report in 9 per cent. Stubenbord[5] had 63 per cent, 28 per cent and 9 per cent, respectively. In this series of 439 cases, involvement of the lymph glands was present in 58 per cent, absent in 39 per cent and not mentioned in the report in 3 per cent. Thirty tumors were found to be inoperable through the primary axillary incision, and 17 of the patients died within one year of their examination. No trace of the others could be found.

TABLE 2.—*Involvement of the Axillary Lymph Nodes in Mammary Carcinoma*

Author	Nodes Not Involved, Patient Living and Well		Nodes Involved, Patient Living and Well	
	5 Years, Percentage	10 Years, Percentage	5 Years, Percentage	10 Years, Percentage
Harrington[9]	63.6	44.1	24.3	13.4
Bunts, Frank E.: Ann. Surg. **76**: 341, 1922	35.0	18.0	20.0	8.8
White, W. C.: Ann. Surg. **86**: 695, 1927	70.0	57.0	19.0	10.0
Guthrie[10]	65.5	40.9	23.0	9.8

Gross evidence of axillary and cervical metastases was not present in all of the cases included, but microscopic examination revealed their presence, showing that metastatic carcinoma occurred much more frequently than nonmetastatic carcinoma. This may mean that involvement of the lymph glands occurs earlier than is suspected, but it more probably indicates in many cases neglect by the patient to attend to the smallest lump in the breast immediately on its discovery. In this connection the conclusions of Medical Report no. 34 of the British Ministry of Health[20] are interesting. They illustrate the extreme importance of undertaking the complete operation while the lesion is still confined to the breast and show that 90.1 per cent of patients in whom the lesion was thus limited were alive ten years after the operation, while 91.3 per cent of patients with axillary involvement were dead

20. The Late Results of Operation for Cancer of the Breast, Medical Report no. 34, British Ministry of Health, London, His Majesty's Stationery Office, 1926; cited in At the Heart of the Cancer Problem, editorial, Am. J. Surg. **27**:187, 1935.

within ten years after the operation. Of patients having advanced carcinoma, 94.4 per cent were dead within ten years.

Education, of course, is the most potent weapon available to physicians in dealing with this phase of the disease. In the words of Sir George Newman: "Not 25 per cent of women with cancer of the breast obtain surgical treatment before their disease has gotten beyond the first stages." He said: "It is not because the disease advances rapidly. . . . The prime need in reducing mortality . . . is not extended hospital accommodations, not improved methods of treatment nor even diagnosis . . . it is avoidance of delay." The essence of the situation is to make sure that cancer of the breast is recognized immediately and is immediately treated.

To teach the laity the significance and the potential danger of a tumor in the breast would mean, in many cases, an earlier visit to the physician. To be sure, many more cases of almost certainly benignant tumor would be seen, but in the presence of that word "almost" lies danger. To make certain the presence or absence of danger the tumor must be removed and examined by a competent pathologist. The patient should be told the possibilities of the diagnosis, and permission should always be obtained for a radical operation in the event that a malignant lesion is found. Using this approach of complete frankness, one seldom encounters a patient who will not cooperate in every way.

Routine roentgen examination of the chest and the pelvis should be done in cases of carcinoma of the breast, because of the large percentage of metastases to these areas. Lenz and Freid [21] reported that in nearly 50 per cent (81 cases in a series of 168) of their cases such skeletal metastases were present, and Schreiner and Stenstrom [6] reported that in 45 per cent of their cases metastases occurred in the chest, the spine and the long bones.

OPERABILITY

The simplest definition of operability from the clinical standpoint is that advocated by Lee,[14] who stated that a tumor of the breast is operable when it is not fixed to the wall of the chest, whether or not the axillary lymph nodes have been invaded. In an inoperable cancer one or more of the following factors are present: Fixation of the tumor itself to the wall of the chest (with fixed axillary nodes); involvement of the supraclavicular or of the opposite axillary nodes; metastases to the chest or to bones; diffuse subcutaneous nodes; diffuse inflam-

21. Lenz, M., and Freid, J. B.: Metastases of the Skeleton, Brain and Spinal Cord from Cancer of the Breast and the Effect of Radiotherapy, Ann. Surg. **93**:279, 1931.

matory cancer involving a wide cutaneous area; remote metastases. In such cases radical amputation should be withheld for two reasons. First, radical surgical operation on a debilitated patient shortens the life of the patient, and, second, it may bring discredit to surgery in the minds of the people. Cases must be chosen in which the tumor is really "operable." This in no wise indicates an unwillingness to perform palliative operations when they are indicated. The patient or, better, the relatives should be impressed with the fact that medical attention has been sought too late and that had the cancer been seen in its earlier stages it would probably have been amenable to surgical treatment. In 7 per cent of cases in this series the tumor was inoperable.

OPERATIVE TREATMENT

The modern conception of the radical operation for cancer of the breast derives from Halstead and from Willy Meyer. The evolution of the operation was well described by Rodman and its technic by Harrington.[9] Unfortunately, the necessity for this radical operation is not universally appreciated, and various less radical procedures are still widely practiced, always with poorer results and fewer cures. In the less radical procedures the attempt is usually made to preserve the pectoralis minor muscle, and in many of them too much skin is preserved over the breast. Handley demonstrated the presence of invasion of the pectoralis muscle (Guthrie[10]) and the necessity for its removal.

Little of note has been added to knowledge in recent years of the requirements of technic in operations for cancer of the breast. Rodman (Guthrie[10]) in 1908 described an operation which embodies the essential principles required for the thorough surgical removal of a breast with a malignant tumor. There are two main principles: First, the operation must be complete enough to remove all probably involved tissue within the limits of reasonable surgical access; second, the steps of the operation should be so carried out that outgoing lymph streams are blocked off early in the operation, thus guarding against dissemination of malignant cells. To accomplish this last requirement Rodman emphasized the primary axillary dissection, with removal of the axillary tissue in one mass as a gland-bearing fascia.

It is possible also in the primary axillary attack to investigate the extent of metastases and to decide whether or not the complete operation is justifiable.

The standard radical operation, as carried out at the Guthrie Clinic, involves the following points: A wide area of skin must be removed; in no case should it be less than 2 inches (5 cm.) equidistant from the growth. Rodman's primary incision is a straight incision beginning 1 inch (2.5 cm.) below the clavicle and about 1½ inches (3.7 cm.) medial to the sulcus between the deltoid and the

pectoralis muscle. It parallels the sulcus. This type of incision does not extend to the arm and obviates the possibility of scar formation which may contract and limit abduction. The axilla is exposed by dividing the tendons of the pectorales at their insertions. As a rule the clavicular portion of the pectoralis major is not removed unless the growth is in the upper cut portion of the breast. The acromiothoracic and the long thoracic arteries run parallel (above and below, respectively) to the tendon of the pectoralis minor muscle and should not be injured during this step of the operation. By the cutting of the costocoracoid membrane the space of Mohrenheim is well exposed.

The dissection of the axilla begins at the apex and extends from above downward and from within outward. As the sheath and the fat are removed from the axillary vessels, the acromial long branch, the alar thoracic branch and the subscapular branch of the axillary artery are encountered in the order named. These, with their accompanying veins, are drawn out and the proximal ends ligated. No attempt should be made to remove individual enlarged glands. The contents of the axilla should be removed en masse as a gland-bearing fascia. When this dissection has been completed nothing is left on the inner aspect of the axilla but the posterior thoracic nerve of Bell and, posteriorly, the long subscapular nerve.

The breast is removed by an incision beginning at the middle of the primary incision, encircling the breast and extending downward to a point halfway between the ensiform appendage and the umbilicus. The oval should be 5 or 6 inches (12 to 15 cm.) or more at its greatest breadth, and the incision should never come within 2 inches (5 cm.) of the edge of the growth. The subcutaneous tissues are cut on a slant so that the skin in every direction is undermined for a distance of several inches from the edges of the wound.

American as well as English surgeons, following the precept of Handley, are practicing extensive deep resection of the fascia in order to prevent peritoneal invasion by malignant cells, which extends along fascial planes, particularly the rectus. The prevention of dissemination and contamination during the operative procedure is also a matter of prime importance. Dissemination may take place during the operation through uncut lymphatics, and for this reason manipulation or squeezing of the breast should be carefully avoided. Important in this consideration is the suggestion of Willy Meyer, who began the operation in the axilla, dividing the lymph vessels at their highest point before the breast was handled at all. Thus the routes of dissemination were cut off.

Jackson[22] believed contamination to be the cause of local recurrence in many cases. Malignant cells escape from the lymph channels of the breast and, becoming implanted in the wound after closure, readily develop into new growths. While this idea is not demonstrable, it is plausible. To prevent such contamination, the flaps, as they are dissected laterally, are reflected and covered with wet packs, and as the dissection proceeds more packs are added, going down on the chest wall. This serves a double purpose, as much heat is prevented from radiating from the large denuded surface and the degree of shock is thereby lessened.

Closure of the wound is begun where the first incision was made, near the clavicle; closure of the oval is begun at the sternal end. After advancing one-third of the distance it can be determined whether the flaps can be approximated readily. If this is impossible the axillary portion of the wound is closed for one-

22. Jackson, J. N.: The Requirements of Technique in Operations for Cancer of the Breast, Ann. Surg. **72**:181, 1920.

third of the distance. The central one-third, which can not be approximated, is covered by Thiersch grafts taken from the thigh. Drainage is not employed except when the patient is fleshy or when the field is wet. Early active motion is encouraged.

In conclusion, a significant group of figures is presented. One may assert that the greatest advance in the past decade both in securing improved results and in saving life lies in the fact that patients come earlier to the surgeon for treatment. That patients do come earlier is obvious when one studies the comparative statement of the average duration of the disease from the time of appearance of the first symptom to the time of the operation (table 3).

This result may in part, at least, be attributed to the work of the American Society for the Control of Cancer. It is earnestly hoped that further advances will be made in the knowledge of the nature of cancer, in methods of diagnosis and in improved treatment by operation, but it is certain that by far the most effective means of saving life and

TABLE 3.—*Duration of Mammary Cancer Before Operation*

	1910-1922	1923-1935
Average duration	65 weeks	55 weeks
Patients who came to operation within 1 year	43.3%	55.5%
Patients who came to operation within 6 months	31.4%	40.4%
Patients who came to operation within 1 month	7.2%	23.2%

ameliorating suffering from cancer of the breast at the present time lies in the early diagnosis of the lesion and its prompt removal by radical means.

SUMMARY AND CONCLUSIONS

Perhaps no disease has received more intensive study than has cancer. Yet it is generally agreed that cancer, one of the chief destroyers of mankind, remains essentially a mystery.

Chronic mastitis, stagnation, previous involutional or inflammatory changes and trauma are believed by many to be important predisposing conditions.

Malignant tumor of the breast is especially prevalent in the fourth and fifth decades of life. It is seldom found in persons under the age of 20 years.

About 1 per cent of malignant tumors of the breast are found in male patients.

Cystic disease is not believed to be a precancerous lesion, and malignant changes are no more likely to develop in a breast showing the disease than in one which is entirely normal.

All single solid tumors of the breast should be removed for diagnosis. While the diagnosis of carcinoma can in the majority of cases be made from the gross tissue at the operating table, a competent pathologist with facilities for examining frozen sections should be available for the 10 or 20 per cent of cases in which this is not possible.

Mammary cancer is found more often in married women than in unmarried women. This comparative frequency prevails to such an extent that one suspects that the incidence of mammary cancer in married women is dependent on some definite factor.

Cancer of the breast seems to appear slightly earlier in those patients who are unable to meet the physiologic demands of pregnancy and latest in those who have never been pregnant.

Cancer can be cured, but early diagnosis and appropriate treatment are absolutely necessary. Thousands of persons with lesions of proved malignancy have been restored to health for periods up to ten or more years through surgical treatment or irradiation, alone or in combination. Biopsy of material taken from questionable lesions is by far the best policy.

Salient features to be considered in differentiating between benign lesions and cancer are presented from the clinical and gross pathologic standpoint.

Cases in which there is involvement of the lymph glands decidedly outnumber those in which there is no such involvement. In the former group the mortality at the end of ten years is about four times that in the latter group.

Definite metastases in the supra-clavicular region are a contraindication to surgical treatment, as is also large extension to the axilla, because, first, life is endangered and, second, discredit may be brought to surgery in the minds of the laity.

Continued education of the laity is one of the best weapons in the fight against malignant tumors. One often hears the remark made that publicity and propaganda do more harm than good, because of the alarm and terror they may arouse in an ignorant and unintelligent public. The argument is specious. The imaginary horror is not nearly so harmful as the actual terror that accompanies malignant disease.

At present, radical operation for cancer of the breast permits a number of different incisions but is commonly understood to demand the removal in one piece of the following structures: the breast (with all the skin over the breast), the pectoralis major and pectoralis minor muscles, the axillary contents (with the exception of the vein, the artery and the brachial plexus) and the deep fascia from clavicle to epigastrium and from sternum to latissimus.

Patients during the last decade have been coming to operation earlier by a few weeks than those of the previous ten years.

PROBLEMS IN THE SURGICAL TREATMENT OF RENAL CALCULI

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Montaigne, the great philosopher of the sixteenth century, has given a most graphic description of the symptoms of "stone," tinged by the unmitigated reality of personal experience, since he himself was a sufferer for many years:

> Thou art seen to sweat with pain, to look pale and red, to tremble, to vomit well nigh to blood, to suffer strange contortions and convulsions, by starts to let tears drop from thine eyes, to urine thick, black, and frightful water, or to have it suppressed by some sharp and craggy stone that cruelly pricks and tears thee.

However, he never reached "such a degree of despair as to bellow and make uproar." He traveled much, seeking a cure at the various watering places of Europe, but without success.

Through the centuries the cause of the formation of stone remained obscure. However, during the last few years knowledge of the causes and prevention of urinary lithiasis has been greatly augmented by painstaking research on the part of numerous investigators. This knowledge has served to emphasize the fact that the surgical removal of stone from the urinary tract is but incidental to a general plan of treatment. The occurrence of stone must be considered a manifestation of some underlying disease, and every effort should be made to discover what etiologic factors are responsible in the individual case. After the elimination of calculi from the urinary tract intelligent follow-up treatment must be carried out to prevent recurrence.

The present highly developed instrumental armamentarium and diagnostic equipment have made exploratory operations on the genitourinary tract practically obsolete. With accurate diagnosis at his command, the surgeon's mind should be made up before he operates, and not at the operating table. However, with respect to urinary calculi, the choice of treatment often presents problems which tax the ingenuity, experience and skill of the urologist to the utmost. The surgical treatment of renal calculi often presents difficulties, certain phases of which perhaps have not been sufficiently stressed. For this reason, a few of the surgical problems arising in the course of my personal experience are presented for consideration.

Read before the New York Academy of Medicine, Jan. 20, 1937.

THE MEDIUM-SIZED CALCULUS IN THE RENAL PELVIS

Probably the easiest of all operations on the kidney is the removal of the uncomplicated medium-sized stone (from 1 to 3 cm. in dimensions) from the renal pelvis (fig. 1). Provided the ureter and pelvis are not surrounded by dense adhesions (periureteritis and peripyelitis) and no obstructive factor is present necessitating plastic repair of the pelvic outlet, simple pyelotomy is all that is necessary. In the absence of gross infection the incision is closed tightly with interrupted sutures of fine catgut and drainage is limited to a Penrose tube down to the region

Fig. 1.—Stone in the pelvis of the right kidney: (*A*) plain roentgenogram of kidney, ureter and bladder; (*B*) pyelogram. This is a case without complications, suitable for simple pyelolithotomy.

of the pelvis in order to take care of urinary leakage, which may last a few days or may not occur at all.

SURGICAL PROBLEM OF THE SMALL RENAL CALCULUS

No operation on the kidney is approached with as much trepidation in my personal experience as the removal of the small, freely movable stone in the renal pelvis (fig. 2). The smaller the stone or stones the greater is the anxiety. Having seen surgeons on one or two occasions acknowledge failure after a search for a small stone in the kidney, I have gained a wholesome respect for such offenders. They are often

capable of causing greater pain than the larger stones; hence all the more reason for finding and removing them. The problem of locating them may well be likened to the proverbial searching for a needle in a haystack, at least in some cases.

No operation for renal or ureteral stone should be undertaken without a plain roentgenogram taken immediately before the operation. The film should be hung in the operating room to guide one's approach to

Fig. 2.—Small ball valve stone in the pelvis of the left kidney. The small renal stone often presents a difficult surgical problem because it may be elusive.

the stone. However, manipulation of the kidney incidental to exposure may cause the stone to shift its position and retreat into the dark recesses of the kidney, where it may elude probing or palpation through a pyelotomy incision. In exposing the kidney, one should as soon as possible isolate and occlude the ureter below the pelvic outlet to prevent possible escape of the stone in that direction. In case the stone cannot be found on careful exploration through the incision in the renal pelvis a roentgenogram of the kidney at the operating table may be of material

assistance in locating it. However, even this assistance may be of no avail, as happened in the case illustrated in figure 2.

The patient was a young woman with severe colic resembling epileptiform convulsions, poorly controlled by morphine and atropine in generous doses. A ureteral catheter relieved pain by pushing the stone away from the pelvic outlet, but recurrence of pain soon followed the removal of the catheter. The description of the operation (Nov. 26, 1928) is as follows: A subcostal incision was made running from the costovertebral angle anteriorly and downward for a distance of about 5 inches (12.5 cm.). Incision was continued through the muscles to the retroperitoneal fascia, no nerves and practically no bleeders being encountered. The costovertebral ligament was cut in order to give adequate exposure. When the retroperitoneal fascia was opened, the lemon yellow fat about the kidney was seen. The lower pole of the kidney and in turn the ureter were readily exposed. A ½ inch (1.3 cm.) tape was passed beneath the ureter to serve for traction. The ureter was followed up toward the kidney, and a small pelvis, intrarenal in type, was found. There was some reaction about the pelvis, so that it was difficult to get a good exposure until the adhesions had been broken up and the bleeding stopped. Two 00 catgut retention sutures were placed in the pelvis just above the ureteropelvic junction and a small incision made between them. In an attempt to grasp the stone with forceps through the incision it was pushed up into the renal pelvis, and it was impossible to locate it again. It was a small stone, less than 0.5 cm. in diameter. Ordinarily such a stone would pass down the ureter, but because the patient had been suffering terrible agony for two weeks and the stone had not got further than the ureteropelvic junction, it was deemed advisable to remove it surgically.

The upper pole of the kidney was then freed and the kidney brought into the wound. Still careful palpation and probing failed to locate the stone. Therefore, the roentgenologist was called in, with his portable machine, and an exposure was made to try to determine the new location of the stone. In the picture thus made the stone showed clearly and from all appearances seemed to be still in the pelvis. Probing through this opening failed to reveal it. A Mayo hemostat was introduced through the opening, and no grating sensation of the stone could be felt anywhere. When the hemostat was withdrawn a clot of blood was seen to protrude from this opening. This was removed and another attempt made to palpate the stone in the kidney. While this was being done the nurse discovered the stone buried in the middle of the clot which had just been removed. The clot of blood completely disguised the stone and made it impossible to detect it by palpation or to get any grating sound on a metal instrument. After this fortunate occurrence closure was begun. The two incisions in the pelvis and ureter were closed with 00 catgut sutures, a piece of fat being placed over the incision and tied in with a suture. A tubular rubber dam for drainage was placed in the region of the renal pelvis and brought out through the posterior angle of the wound. The muscles were closed in two layers with continuous lock sutures of no. 2 chromic material. The subcutaneous tissues were approximated with interrupted sutures of 00 catgut. Skin was closed with a continuous lock suture of dermol. The wound was dressed with tincture of benzoin. The patient was given a hypodermoclysis on the table and returned to her room in good condition.

Here was an urgent and clearcut indication for operation, and yet the stone could not be found. When I was about to give up in despair the nurse at the operating table said, "Here it is" and showed me the

stone extracted from a small blood clot which had been removed from the renal pelvis. The nurse was properly rewarded for her alertness, and my respect for the small renal calculus was further enhanced.

A similar problem arose in connection with the case illustrated in figure 3.

To make matters worse, the renal pelvis was intrarenal in type, so that the little finger could not be inserted in the hope of palpating the stone. Furthermore, the stone eluded the grasp of the forceps, and no grating sensation could be elicited by probing into the calices. As a last resort the hydraulic maneuver illustrated in figure 4 was utilized, with gratifying results. A small soft rubber catheter was inserted into the renal pelvis, and the pyelotomy incision was closed tightly about

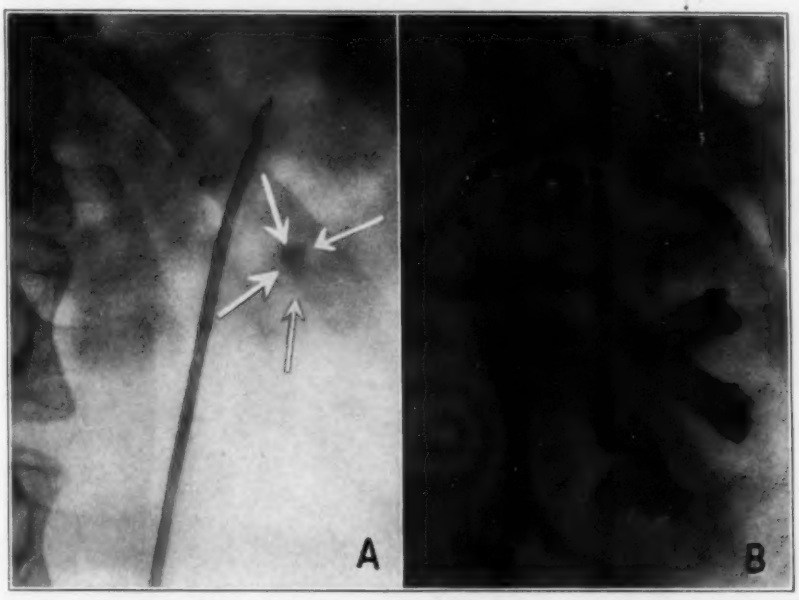

Fig. 3.—Small renal stone (*A*) in pelvis of kidney (*B*). The pelvis is intrarenal in type and the stone freely movable, having ready access to all the calices. The surgical problem of finding such a stone may be most difficult unless one resorts to the hydraulic maneuver described in the text and illustrated in figure 4.

the catheter by pressure of thumb and forefinger, while an assistant with a 10 cc. Luer syringe injected physiologic solution of sodium chloride with some force. When the pelvis and calices were fully distended the catheter was suddenly withdrawn. The sudden outrush of fluid created a strong outward current, which carried the stone with it. The stone was found (to the great relief of all present) reposing on the gauze sponge previously placed beneath the renal pelvis.

The point which makes the difference between success and failure in the hydraulic maneuver is that the same principles must be followed as in the evacuation of small stones or fragments of stones from the bladder following litholapaxy. It does not suffice to insert a catheter or

the point of a syringe into the pelvis and flush the kidney. The solution merely runs back out of the pyelotomy incision around the catheter or syringe. The incision must be kept closed tightly while the injection is made, and it is preferable to flush back and forth just as with the bladder evacuator, in order to set up a current of sufficient force within the kidney to set the stone in motion. Then during the phase of complete distention the syringe or catheter is suddenly removed and the outrushing of fluid allowed to carry the stone with it. Figure 5 illustrates

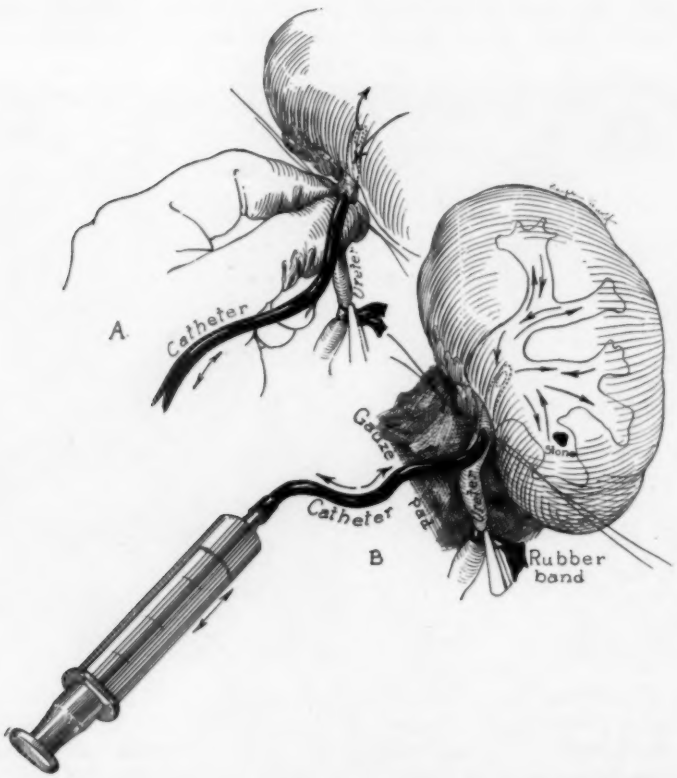

Fig. 4.—Technic of the hydraulic maneuver, of value in removing the small renal calculus which escapes detection by other means. This procedure was used in the case illustrated in figure 3. The pelvis is intrarenal in type, a circumstance which always makes the surgical problem more acute. The same principles apply here as in the evacuation of small stones or fragments of stone from the bladder. Note that in *A* the thumb and forefinger keep the opening in the ureter tightly closed to prevent the escape of the fluid around the catheter while the injection is being made. Forcible to and fro movements of the piston (shown in *B*) set the stone in motion. After a final forcible injection the catheter is suddenly withdrawn, and the stone is carried out through the opening in the ureter with the outrushing current of fluid and is seen reposing on the gauze sponge beneath the ureter.

the use of an asepto syringe in the extrarenal type of pelvis. Probably an ordinary ear syringe would be even more satisfactory, but I have not had occasion to use it. Figure 6 represents a purely theoretic application of the McCarthy evacuator in cases of hydronephrosis with multiple small calculi. The hydraulic maneuver, if it may be dignified

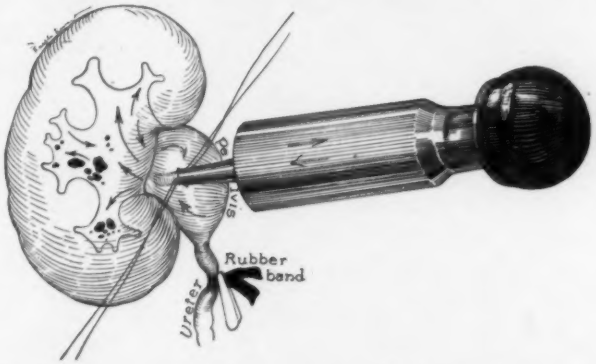

Fig. 5.—Application of the principle illustrated in figure 4 to a case of multiple small calculi in which the pelvis is of extrarenal type. An ordinary asepto bulb syringe was used.

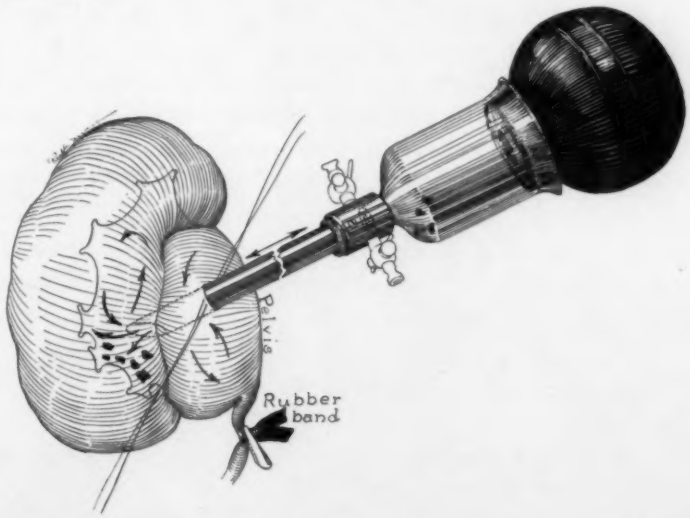

Fig. 6.—Hypothetic use of the McCarthy evacuator in a case of small calculi in a large hydronephrotic kidney.

by such a term, not only is of great value in dealing with the small, elusive renal calculus but should occasionally prove valuable in the eviction of unsuspected stones. Braasch and Foulds (1923) in reviewing 1,079 operations for stone noted that multiple stones were found at operation in 146 cases in which a single shadow was seen in the roentgenogram.

URETHRAL SPLINT AS APPLIED TO PROBLEM OF FORMATION OF STRICTURES WITH SECONDARY HYDRONEPHROSIS AFTER PYELOLITHOTOMY

Not infrequently one is surprised to find a presumably easy pyelotomy for stone complicated by dense adhesions about the upper part of the ureter and the renal pelvis. Routine urologic investigation prior to operation may give no inkling of their presence, which may make an otherwise simple operation very difficult. It is in cases of this sort particularly that unfavorable late results occur in the form of refractory or impenetrable stricture and ultimate destruction of the kidney by secondary hydronephrosis. The patient may have no symptoms, and such a result may pass unrecognized unless urographic studies are made after operation. Patients are prone to think that an operation should end the necessity for instrumental manipulation, and deference to their objections often influences the urologist to neglect this extremely vital follow-up program, with the result that in an occasional case the kidney becomes permanently damaged or functionless. A few unfortunate experiences of this sort have convinced me that no patient should be allowed to leave the hospital after pyelotomy or ureterotomy without ureteral catheterization and dilation and pelvic lavage to be sure the ureter is free from kinks and strictures and that no residual infection remains to favor the recurrence of stones and the development of hydronephrosis. As a further precautionary measure to prevent such disastrous end results, I believe the use of the ureteral splint at operation is definitely indicated, at least in all cases in which evidence of previous periureteritis and peripyelitis exists in the form of dense adhesions about the ureter and pelvis. An indwelling ureteral catheter may be placed cystoscopically before operation, and if deemed advisable a second catheter may be passed in a retrograde manner during the operation and left in place for several days postoperatively so as to secure a straight ureter with good drainage and to prevent kinking, formation of stricture and urinary stasis.

The result of neglecting these fundamental principles is well shown in the 2 cases illustrated in figures 7 and 8.

Pyelolithotomy in both cases was rendered difficult by the presence of dense adhesions about the upper part of the ureter and pelvis. No ureteral splinting was utilized at operation. As a result marked distortion and stenosis of the upper part of the ureter and of the pelvis developed in both cases, with resultant hydronephrosis. In 1 (fig. 7) after several attempts the renal pelvis was successfully entered by ureteral catheter through the cystoscope. In the other (fig. 8) all attempts proved unsuccessful, and nephrectomy for infected hydronephrosis was later necessary.

Fig. 7.—Small renal calculus offering a difficult surgical problem for pyelolithotomy because of the small intrarenal pelvis surrounded by dense adhesions due to chronic periureteritis and peripyelitis. The ureteral splint is recommended routinely in such cases. Failure to use the ureteral splint in this case resulted in stricture and distortion of the pelvis and ureter with secondary hydronephrosis following the operation. Dilators were passed after numerous cystoscopies, and the kidney was saved from complete destruction only with the greatest difficulty.

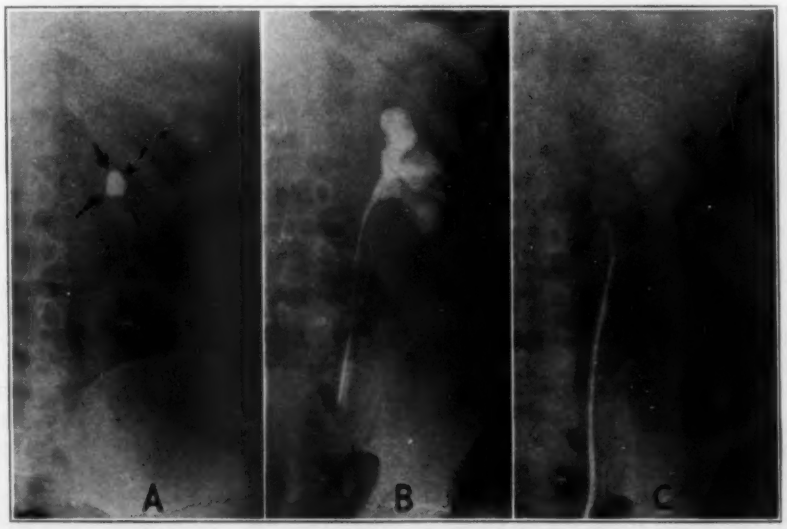

Fig. 8.—Calculus in the pelvis of the left kidney: *A*, plain roentgenogram; *B*, pyelogram. Dense adhesions about the pelvis made the removal of the stone difficult, and failure to make use of the ureteral splint resulted in impermeable stricture of the ureter (*C*) and infected hydronephrosis later requiring nephrectomy.

The ureteral splint may be used in several ways. The catheter may be passed before operation to the renal pelvis through a cystoscope, or a retrograde catheter may be passed down the ureter from above through the pyelotomy wound. Drainage by means of nephrostomy may be combined with ureteral splinting as shown in figure 9 *a* and is advisable in cases of severe infection as well as in all anastomotic procedures and certain types of plastic repair of the ureter and pelvis. Figure 9 *b* shows a method of ureteral splinting without nephrostomy.

This procedure was used in a case of hydronephrosis without infection due to stricture of the pelvic outlet, in which stones were of secondary importance. The lower part of the hydronephrotic sac was cut away, the stones included, the pelvic outlet dilated with a Mayo hemostat and multiple vertical incisions made about it down to the submucosa, as described by David M. Davis (1933), the principle of

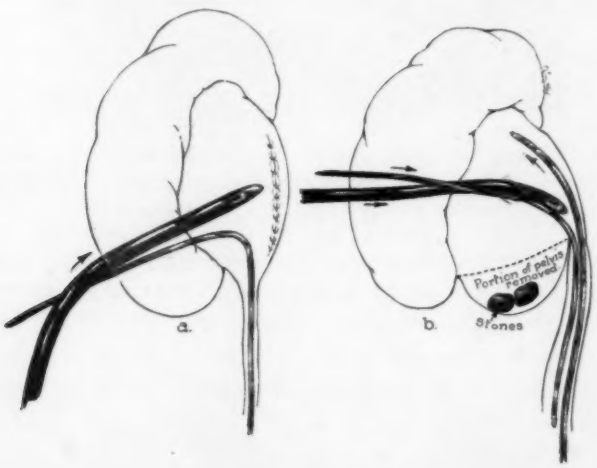

Fig. 9.—Types of ureteral splinting: (*a*) with drainage by means of nephrostomy, (*b*) with drainage by means of pyelotomy. Splinting is advisable in practically all cases of plastic repair of the pelvis or ureter and in all operations for stone in the kidney or ureter associated with periureteritis or peripyelitis. The ureteral catheter is generally the best splint and should be retained in place for a week or more, according to the need of the patient. Use of the principle of the splint will insure a straight ureter and adequate renal drainage. The procedure shown in *b* was followed with excellent results in the case illustrated in figure 10.

the Rammstedt operation for pylorospasm being utilized. Two no. 7 F ureteral catheters were inserted as a ureteral splint and to maintain dilatation of the pelvic outlet. They were left in place six days. The pyelograms (fig. 10) show the condition before operation and the final result seven months after operation.

The ureteral splint is of great value also in preventing distortion and stenosis following operations for stone in the lower ureter (fig. 11), particularly where there is much periureteral reaction. It is advisable

to pass a catheter at cystoscopy before operation, to be left in place during and after operation. If the catheter cannot be passed beyond the stone through the cystoscope, one can pass it on up to the renal kidney pelvis at operation after the stone is removed.

In a case such as that illustrated in figure 11, in which the stone is close to the bladder and a catheter cannot be passed from below, one can follow the procedure used in that case:

After the stone was removed at operation, one end of a ureteral catheter was passed upward to the renal pelvis and the other downward into the bladder through the ureterotomy wound. After six days the end of the catheter which was coiled in the bladder was brought out through the urethra with the aid of the cystoscope.

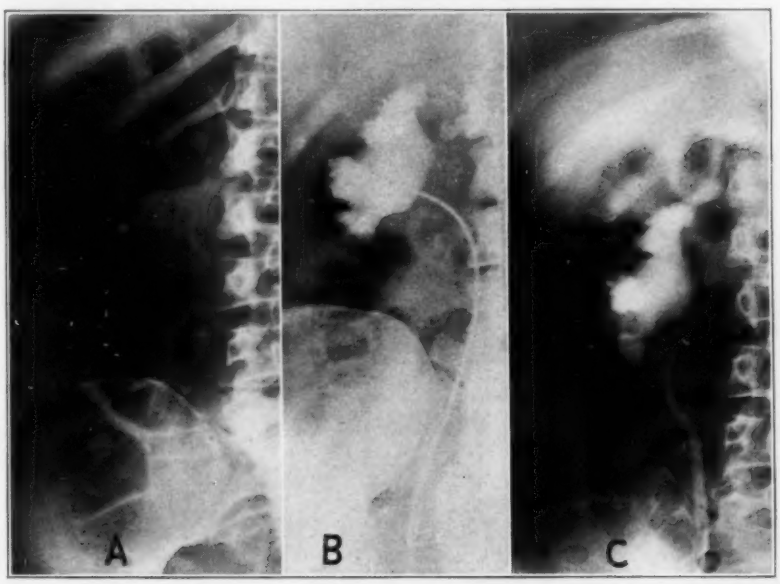

Fig. 10.—Two small calculi (*A*) in the pelvis of a right hydronephrotic kidney (*B*). Hydronephrosis was due to stricture at the pelvic outlet. The operation carried out in this case is shown in figure 9 *b*. In addition, the pelvic outlet was thoroughly dilated with a Mayo hemostat and vertical incisions made externally about the ureteropelvic junction down to the submucosa to allow of maximum patency. A double ureteral catheter was used as a splint and left in place for a week after operation. This kidney also exhibited marked ptosis in the vertical pyelogram, which was corrected by nephropexy. Since the patient was an extremely neurotic young woman, a renal sympathectomy was done to make doubly sure of relieving all pain. The ultimate result is shown in *C* seven months after operation. The kidney has regained perfect function and is free from infection.

Use of the ureteral splint in such cases will definitely prevent the occurrence of distortion, stenosis and urinary fistula, which sometimes make it difficult or impossible to pass a catheter up the ureter afterward.

PROBLEM OF 'CHOICE OF NEPHROTOMY, HEMINEPHRECTOMY OR NEPHRECTOMY IN CASES OF LARGE STONE

The remarkable reparative power of the kidney has impressed urologists of late years, and a conservative trend has grown in renal surgery. Kidneys practically devoid of function are seen to recover to a surprising degree when conscientious treatment is undertaken before operation to eliminate infection and promote free drainage in cases of renal stone complicated by infection and obstruction. Even in cases in which these factors are not present to any degree, the presence of a stone in the kidney appears at times to exert an inhibitory action on

Fig. 11.—Bilateral hydronephrosis, on the right due to ureteral stricture and on the left to two calculi, which appear as one in the lower part of the ureter near the bladder. The stones were removed by a midline ureterolithotomy. A ureteral catheter could not be passed beyond the stones with the cystoscope but was inserted, for the purpose of splinting, through the incision after the stones were removed, one end being passed into the bladder and the other up to the renal pelvis.

function, and at operation one will be surprised to find an amount of healthy-looking parenchyma far beyond expectations based on previous studies of function. Realization of these factors will sometimes result in the saving of a kidney in a case in which nephrectomy was contemplated. Figure 12 illustrates the ideal type of case for partial resection of the kidney rather than nephrotomy in the treatment of renal calculus.

There was a large stone in the pelvis and in addition one in the lower major calix with evidence of gross infection and dilatation about it. The upper half of the kidney was remarkably normal. The best interests of the patient were served by removing this diseased renal tissue with the stones.

Figure 13 illustrates a case in which a large stone was present and in addition the entire kidney was heavily infected, with complete loss of function.

A nephrolithotomy was done with drainage by means of nephrostomy, but the infection did not clear up, and there was no return of function. In this case the treatment employed was too conservative, as later events proved a nephrectomy would have been the procedure of choice.

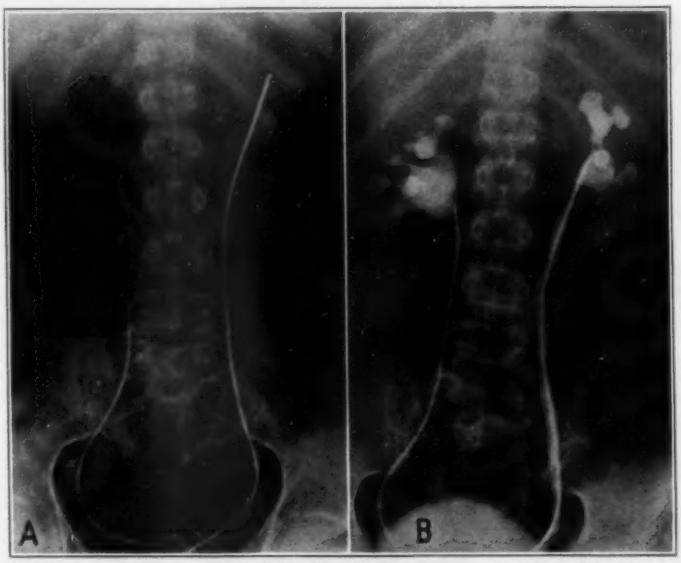

Fig. 12.—Large stones in an ideal case for resection of kidney; *A*, plain roentgnogram of kidney, ureter and bladder; *B*, pyelogram showing their relation to the kidney. The lower pole of the kidney presented a localized pyonephrosis. The abscess about the stone in the lower pole is readily seen in the pyelogram. The parenchyma of the lower pole was destroyed by chronic inflammatory changes. Since the upper two thirds of the kidney appeared normal, the lower third was resected and all the stones removed through this approach. The patient made an excellent recovery.

One must judge from the appearance of the parenchyma at operation and not be influenced entirely by the preliminary urinary and functional findings as to whether to do a nephrectomy or a nephrotomy. Figure 14 illustrates a case in which renal function before operation as measured by the output of phenolphthalein was almost nil, yet after operation there was a return to normal.

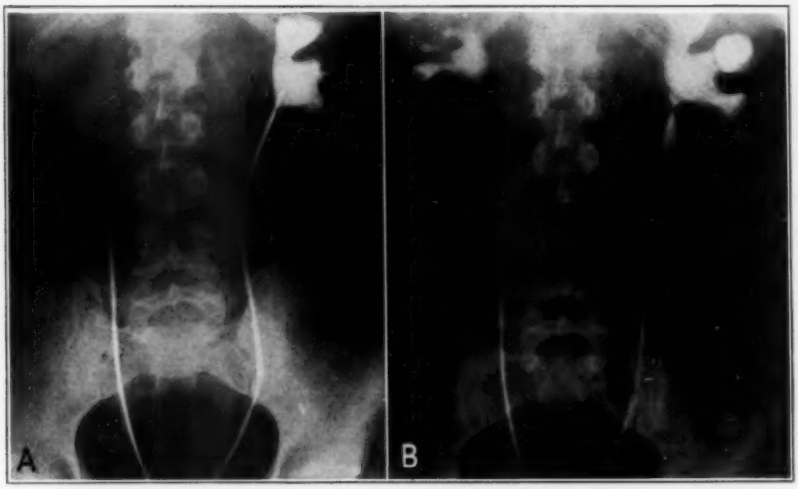

Fig. 13.—Large left renal calculus: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, pyelogram. The stone was removed by nephrotomy, but severe damage to the parenchyma from chronic infection and failure of any functional restoration later proved that nephrectomy would have been the procedure of choice in this instance.

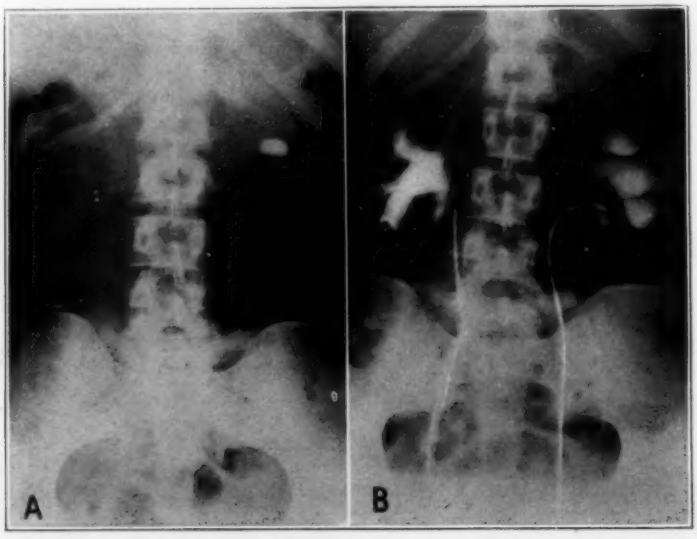

Fig. 14.—Stone in the left kidney in the case of young woman: *A*, plain roentgenogram of kidney, ureter and bladder. The condition was associated with bilateral ptosis, marked kinking of ureters and advanced hydronephrosis on the left, with greatly impaired function. Pyelolithotomy and nephropexy were successfully performed, and the function returned to normal.

PROBLEMS ASSOCIATED WITH BILATERAL RENAL CALCULI

In figures 15 and 16 are shown successive stages of the formation of stones in a woman of 24.

First of all a stone lodged in the left ureter. Attempts to encourage it to pass resulted in perforation of the left ureter with perirenal extravasation of infected urine. A culture of the blood was positive for Bacillus coli. Drainage was instituted through a lumbar incision, and healing occurred after the stone had passed. After this episode a large stone blocked the right ureter. Several smaller stones were present in the right kidney. The right ureteral orifice was slit with ureteral scissors. This procedure was followed by a hemorrhage which filled the bladder with clots and necessitated instrumental evacuation. The stone in the right ureter passed, followed by the smaller ones above. There was marked infection in both kidneys, and every effort was made by diet, medication and frequent renal lavage to clear it up, but without success. During the next year a large stone formed in the left kidney. This was removed by nephrotomy, which was followed by use of a ureteral splint and drainage by means of nephrostomy. During operation hemorrhage from the nephrostomy wound was controlled by a tourniquet on the renal pedicle, consisting of a soft rubber no. 20 urethral catheter held by an assistant. I believe this method is far safer, and endangers the integrity of the kidney less, than the use of any kind of clamp. The operation was difficult owing to the presence of adhesions from the perirenal extravasation of a year before. The wound made by nephrotomy was closed by the ribbon gut method of Lowsley, which appears to be a distinct improvement over the old method of mattress sutures through the substance of the kidney. The infection in both kidneys cleared up promptly, and the function on both sides is now practically normal.

An extreme example of bilateral calculus disease is illustrated in figure 17.

The patient was a woman of 40 with large calculous pyonephrosis associated with perinephric abscess on the left side. On the right side was a calculous pyonephrosis in the lower half of the right double kidney. The excretion of phenolsulfonphthalein was 40 per cent for two hours. The patient was emaciated and practically moribund. A nephrectomy on the left side was done in two stages. The first stage consisted of nephrostomy and drainage of the perinephric abscess. Two weeks later nephrectomy was done. The patient improved remarkably, and in the following year her weight advanced from 84 to 170 pounds (38.1 to 77.1 Kg.). She now enjoys good health, but still retains her calculous pyonephrosis in the lower half of her double right kidney. The question now stands, Should a heminephrectomy be done on this remaining kidney or should discretion be allowed to dictate a hands-off policy? I have favored the latter alternative.

In figure 18 the findings in a woman of 36 are shown.

On the right side was a congenital infantile kidney, not much larger than a golf ball, while the left kidney contained a large staghorn calculus and had undergone replacement fibrolipomatosis. Death occurred as a result of uremia plus sudden exacerbation of infection in this kidney with the formation of perinephritic abscess, generalized peritonitis and septicemia.

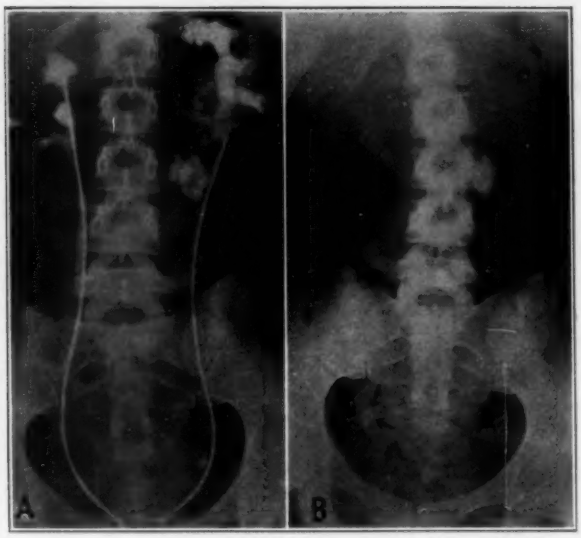

Fig. 15.—Infection with Bacillus coli in both kidneys and formation of multiple stones. In *A* is shown a stone in the lower part of the left ureter and the extravasation of the pyelographic medium about the pelvis of the left kidney. Urinary extravasation and perinephric abscess occurred, necessitating lumbar drainage. The stone was removed cystoscopically. One month later a large stone was seen in the lower part of the right ureter (*B*) and multiple small calculi in the right kidney. This stone was removed cytoscopically and the small ones in the kidney passed spontaneously (fig. 16). A large calcified lymph gland is seen on the left near the spine.

Fig. 16.—Large branching calculus in the left kidney in the case shown in figure 15, one year later. The large calcified gland is shown above the calculus, in a higher position than in figure 15. The calculus was removed by nephrotomy with Lowsley ribbon gut closure. The result was excellent.

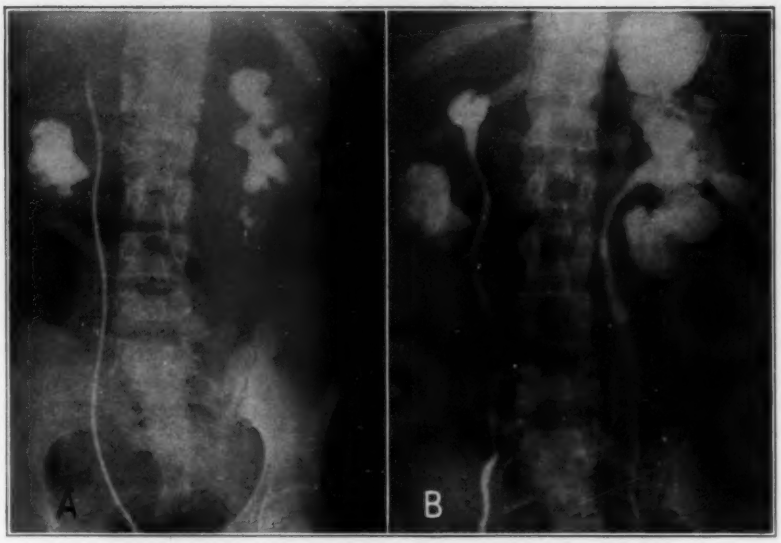

Fig. 17.—Extensive bilateral calculous disease: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, bilateral pyeloureterogram. On the right side is a double kidney with calculous pyonephrosis of the lower half; on the left, complete destruction of the kidney by calculous pyonephrosis with a communicating perinephric abscess at the upper pole beneath the diaphragm. The patient depended entirely on the upper half of the right double kidney for renal function; the excretion of phenolsulfonphthalein was 40 per cent in two hours. A two stage nephrectomy was performed on the left. The patient weighed 84 pounds (38.1 Kg.); one year after the operation she weighed 170 pounds (77.1 Kg.).

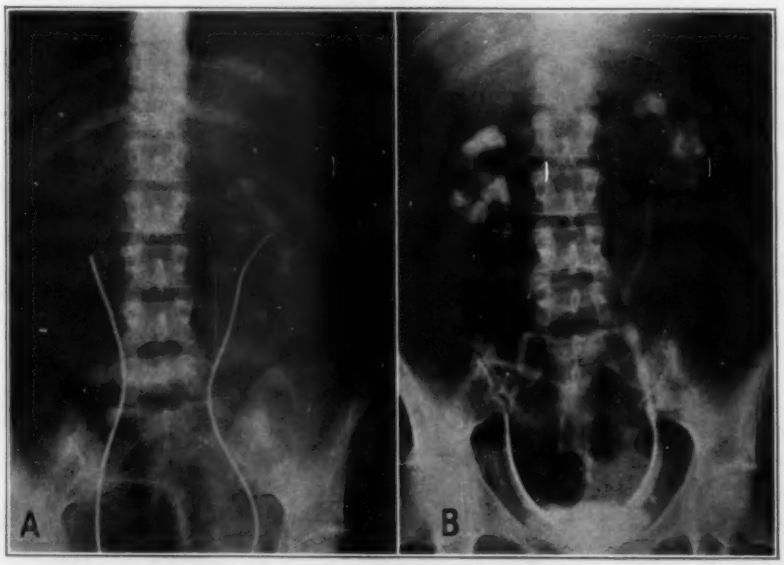

Fig. 18.—Hydronephrotic congenital infantile right kidney and left kidney devoid of function by calculous disease associated with chronic infection: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, bilateral pyeloureterogram. There is also a perinephric abscess on the left side. The patient died of acute peritonitis, septicemia and uremia.

PROBLEM OF CYSTOSCOPIC MANIPULATION VERSUS OPERATION IN MANAGEMENT OF URETERAL STONE

In figure 19 is shown a calculus in the upper part of the ureter which resisted repeated attempts to promote its passage by cystoscopic manipulation.

Finally severe ureteral colic with chills and fever developed, demanding emergency treatment. The stone was pushed back into the renal pelvis with a ureteral catheter at cystoscopy. Four years have passed since then without symptoms, but the patient still has his stone tucked away in a minor calix, and he refuses operation. Early operation would have been better than resorting to so many attempts to secure passage of the stone by cystoscopic manipulation and would have saved the patient a substantial amount of time, disability and suffering.

Fig. 19.—Calculus impacted in the upper part of the left ureter: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, excretion urogram. Repeated cystoscopic manipulations resulted in fever and chills associated with renal colic. The stone was then pushed back into the kidney by a ureteral catheter, where it still remains after four years. Early operation would have been the procedure of choice in this case.

If a stone shows no tendency to pass after a reasonable amount of cystoscopic treatment, it should be removed surgically without further delay. Furthermore, the various types of metallic instruments, which when used judiciously in the lower third of the ureter will often remove calculi, should not be used in the upper ureter under any conditions. Figure 20 illustrates a case in which there was an attack of renal colic on the left side associated with what appeared to be a small stone in the pelvis and a moderate degree of hydronephrosis.

Nothing was done. The patient returned two and one-half years later with a second attack of renal colic. At this time a large hydronephrotic sac was found, requiring nephrectomy.

Such a case indicates the necessity for thorough urologic study and close surveillance in cases of seemingly minor pathologic conditions in order to prevent the eventual destruction of a kidney.

GAS GANGRENE FOLLOWING OPERATION FOR STONES

Fortunately gas gangrene following operation on the kidney for stone is extremely rare, but it may happen most unexpectedly. Figure 21 illustrates a case in which it occurred.

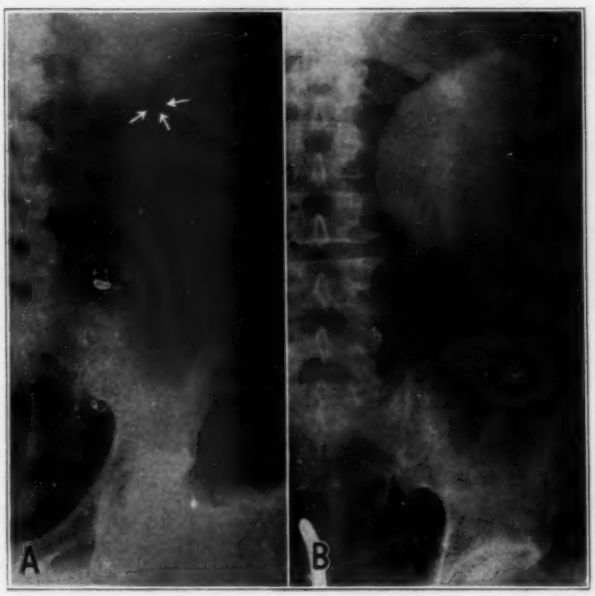

Fig. 20.—Moderate hydronephrosis (*A*) associated with what appears to be a small stone in the lower major calix. The patient refused treatment and came back two and one-half years later with renal colic and a large hydronephrotic sac (*B*) requiring nephrectomy.

Prior to operation the patient suffered with a severe attack of pyelonephritis, and on passage of a large (8 F) ureteral catheter the pus was found too thick to drain through the catheter without diluting it with physiologic solution of sodium chloride. The catheter was left in place for a week and the renal pelvis frequently washed with antiseptics. When the patient's temperature had been normal for several days and the infection was apparently pretty well cleared up, a pyelolithotomy was done and was followed by typical gas gangrene of the wound. Fortunately it responded to anti-gas gangrene serum and the patient recovered.

Recent work has shown the efficacy of roentgen therapy and sulfanilamide in the treatment of gas gangrene, which may rob it of some of its terrors.

HYPERPARATHYROIDISM WITH NEPHROLITHIASIS

In a small percentage of cases hyperparathyroidism is the chief etiologic factor in the formation of renal calculi. This factor is of such importance that the calcium and phosphorus content of the blood should be determined as a routine part of every investigation involving urinary calculi. Figures 22 and 23 illustrate successive stages of formation of stone in such a case.

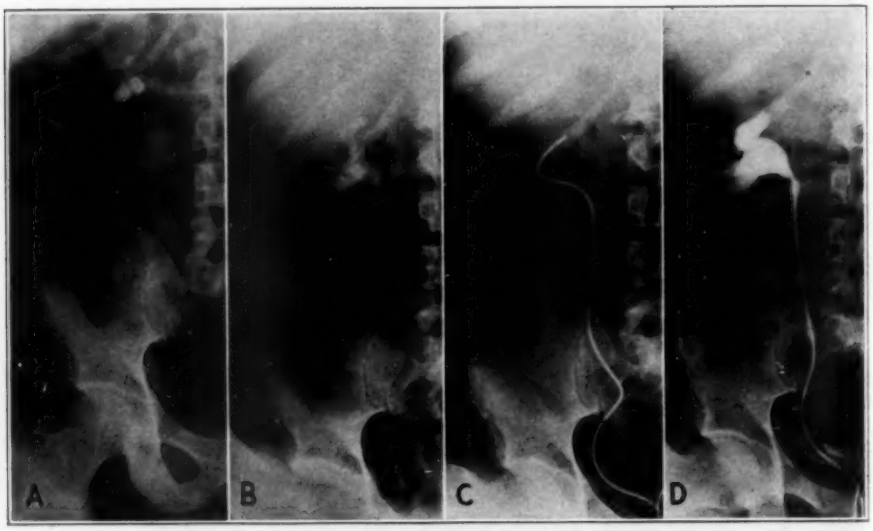

Fig. 21.—Gas gangrene following pyelolithotomy: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, pyelogram. The kidney showed no function, and pus was so thick in the renal pelvis that it would not come through a catheter without dilution. An indwelling ureteral catheter was placed one week before pyelolithotomy. *C*, plain roentgenogram of kidney, ureter and bladder; *D*, pyelogram, three years later. The renal function had returned practically to normal, and no infection was present.

The patient, a man aged 44, was first operated on for a stone blocking the lower part of the left ureter. Roentgenograms showed multiple calculi in both kidneys, including the seedlike concretions in the parenchyma which are characteristic of this disease. After ureterolithotomy, the patient's neck was explored, and a large parathyroid adenoma, weighing slightly more than 10 Gm., was removed. However, the calcium and phosphorus content of his blood did not return to normal as had been hoped. Subsequently, large stones blocked the right ureter, and a second ureterolithotomy had to be done. Later a stone again blocked the left ureter, at the site of the original ureterolithotomy. Cystoscopic

Fig. 22.—Hyperparathyroidism with bilateral nephrolithiasis. Multiple seed calculi are seen in the parenchyma of both kidneys. The impacted calculus in the lower part of the left ureter (*A*) required ureterolithotomy. Later a ureterolithotomy on the right was necessary for two large calculi impacted in the right ureter (*B*).

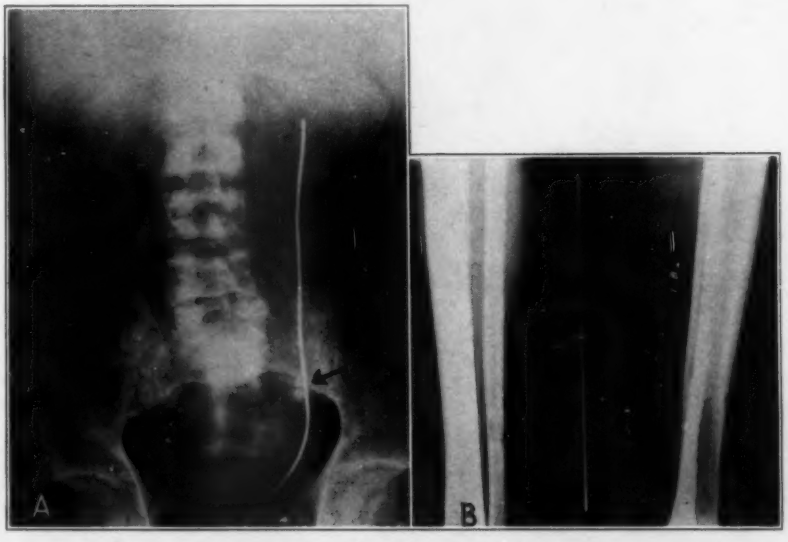

Fig. 23.—Recurrence of two large calculi (*A*) in the lower part of the right ureter in the case illustrated in figure 22, a few months later. Perforation occurred followed by perinephric abscess, generalized peritonitis and death. Osteoporosis characteristic of hyperparathyroidism is evident in the bones (*A* and *B*). After the first operation for stone, a parathyroid tumor weighing 10 Gm. was removed from the patient's neck. The calcium and phosphorus content of the blood remained abnormal. Two more parathyroid adenomas were found at autopsy.

attempts to promote passage of the stones were unsuccessful, and the patient's general condition rendered surgical intervention exceedingly precarious. The ureter was perforated by the stone (perhaps aided by cystoscopic manipulation), and the patient died. Autopsy revealed a perinephritic abscess and general peritonitis with abscess of the spleen, while further examination of the neck revealed one large and one small parathyroid adenoma, which had been missed when the first adenoma was removed. This accounted for the failure of the calcium and phosphorus content of the blood to return to normal.

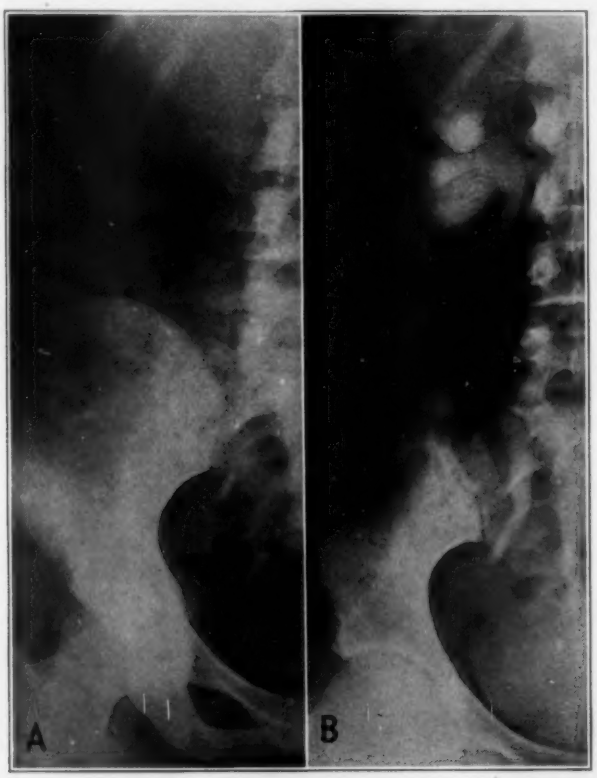

Fig. 24.—Large impacted stone in the right ureter, causing hydronephrosis: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, pyeloureterogram. Ureterolithotomy on the right and appendectomy were performed at the same time through a McBurney incision.

COINCIDENT URETEROLITHOTOMY AND APPENDECTOMY

Figure 24 illustrates the case of a woman of 25, who had more or less discomfort for several years in the right lower quadrant of the abdomen.

During all this time it was taken for granted that she had chronic appendicitis, until urologic investigation revealed a large stone in the lower part of the right ureter. Since cystoscopic removal was obviously out of the question, uretero-

lithotomy through a lateral incision was done without delay. Through the same incision the peritoneum was opened and a normal appendix removed. The patient was convinced that her appendix was at fault, and there seemed to be no valid objection to combining the two operations. In figure 24 the kidney appears to be badly damaged, yet its functional restoration was perfect after removal of the stone.

TOTAL DESTRUCTION OF ONE KIDNEY WITH CALCULOUS PYONEPHROSIS: ANURIA AFFECTING THE NORMAL MATE

Figures 25 and 26 illustrate the case of a woman 45 years of age who exhibited complete destruction of the right kidney by calculous pyonephrosis.

A complete urologic investigation showed the opposite kidney to be normal in every respect. Following cystoscopy, anuria occurred and could not be overcome by any of the usual means. A second cystoscopy was done, and a catheter could not be passed up the left ureter, although it had passed easily at the first cystoscopy. After six days of total anuria, pyelotomy was performed on the left. The pelvis and ureter were distended with urine which gushed forth freely. Retrograde catheterization of the left ureter was done. The wound healed promptly, and normal urination was reestablished. The nature of the obstruction in the left ureter causing the anuria still remains a mystery. The patient would not submit to further treatment and was discharged from the hospital. In spite of the presence of a large calculous pyonephrosis she enjoyed fair health for four years. Severe pain then developed in her right side, with chills and fever, and she was persuaded to come back to the hospital, where nephrectomy was performed on the right, with a successful outcome.

PROBLEMS OF STONE IN CONNECTION WITH RENAL TUBERCULOSIS

Calcification is demonstrable by roentgenography in from 10 to 20 per cent of cases of renal tuberculosis. However, the combination of stone and renal tuberculosis is comparatively uncommon.

Figure 27 illustrates a case of renal tuberculosis associated with stone in the lower part of the ureter.

The surgical problem was whether to do the usual nephrectomy or a nephroureterectomy. A simple nephrectomy was done, with an excellent result. The patient has been followed closely for five years since operation, and the stone in the stump of the tuberculous ureter has never caused the least trouble.

Figure 28 illustrates a case of tuberculosis of the left kidney with stone in the pelvis of the right kidney.

The patient, aged 30, had Potts' disease as a child. Nine years previously I had performed bilateral epididymectomy for tuberculosis. Two years before he had had an active pulmonary lesion, which became quiescent after a year in an Arizona sanatorium. Since it was thought best to preserve the integrity of his right kidney, pyelolithotomy was done on the right. One year has passed since that operation, but so far, because the tuberculous left kidney is silent and he has no symptoms of disorder in the bladder, he has refused nephrectomy.

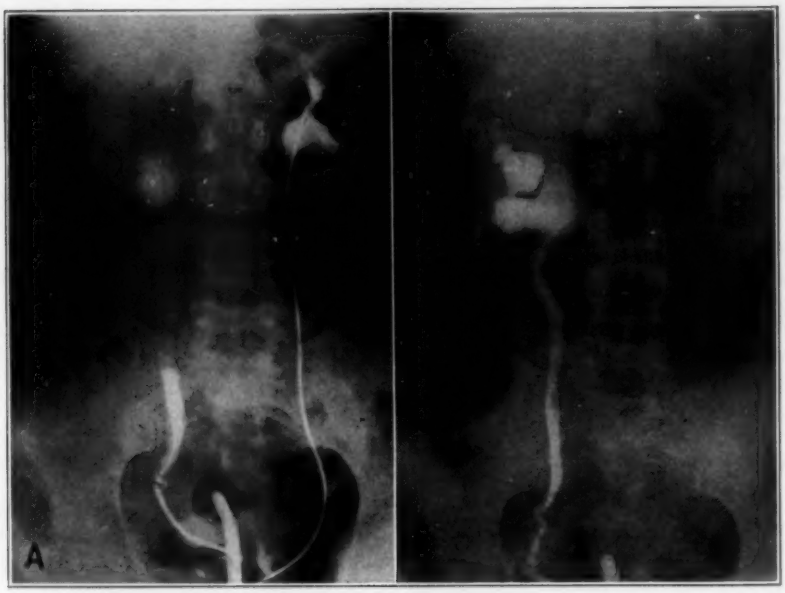

Fig. 25.—Calculous pyonephrosis (right) and normal left kidney. The bilateral pyelogram (*A*) shows the stone in the right kidney, but the pyelographic medium fills only the lower part of the ureter, where an S-shaped strictured area is seen. The stricture probably resulted from complications associated with difficult labor. In *B* is shown a pyeloureterogram of the same kidney partially filled with sodium iodide. Nephrectomy on the right was planned, but after cystoscopy the patient had anuria for six days owing to blockage of unknown cause in the lower part of the left ureter. Pyelotomy on the left and retrograde catheterization of the left ureter overcame the anuria (fig. 26).

Fig. 26.—Intravenous urogram in the case illustrated in figure 25, four years later. Note the deformity on the left resulting from the previous operation to cure anuria. Nephrectomy was now performed on the right and the large calculous pyonephrosis removed. During the previous four years the patient had been free from symptoms, but she came for operation because of an attack of pain in the right side associated with chills and fever and acute perinephric involvement.

Fig. 27.—Stone remaining in a tuberculous left ureter six years after nephrectomy for tuberculosis of the left kidney. The patient is well and free from symptoms.

Fig. 28.—Plain roentgenogram of kidney, ureter and bladder in a case with old Pott's disease, tuberculosis of the left kidney and calculus in the right renal pelvis. Pyelolithotomy was performed on the right.

CONFUSION OF EXTRARENAL SHADOWS WITH RENAL STONE

Usually no difficulty is found in determining whether a given concretion is in the urinary tract or extraurinary, but occasionally special procedures are necessary to settle this point. The stereogram with ureteral catheter in place is often helpful, or a lateral exposure, as in the case illustrated in figure 29, will definitely determine this point.

SPONTANEOUS DISAPPEARANCE OF LARGE RENAL CALCULUS

The case illustrated in figures 30 and 31 is reported as a curiosity without any attempt at explanation.

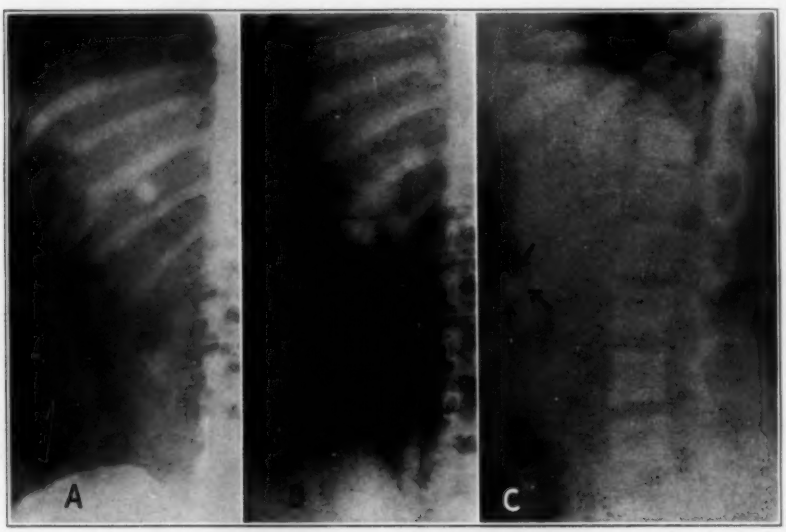

Fig. 29.—Renal colic on the right, associated with infected hydronephrosis: *A*, plain roentgenogram of kidney, ureter and bladder, showing the stone, which in the pyelogram (*B*) appears to be situated in the upper major calyx. The lateral view (*C*) proves that this is a gallstone because of its anterior position. A renal stone would be in the same plane as the spine.

The patient, a man 48 years of age, came to the Southern Pacific Hospital suffering with renal colic. Urologic investigation revealed large bilateral renal calculi of the staghorn type associated with chronic pyelonephritis (fig. 30). Since function was most impaired on the right, a nephrolithotomy was done on that side. The patient was then sent home to recuperate, with instructions to return within a month for operation on the left kidney. He did not return for four years. Investigation then showed (fig. 31) that the large staghorn calculus in the left kidney had apparently disappeared spontaneously. His pyuria had likewise cleared up, and there was no evidence of recurrence on the right side. During these

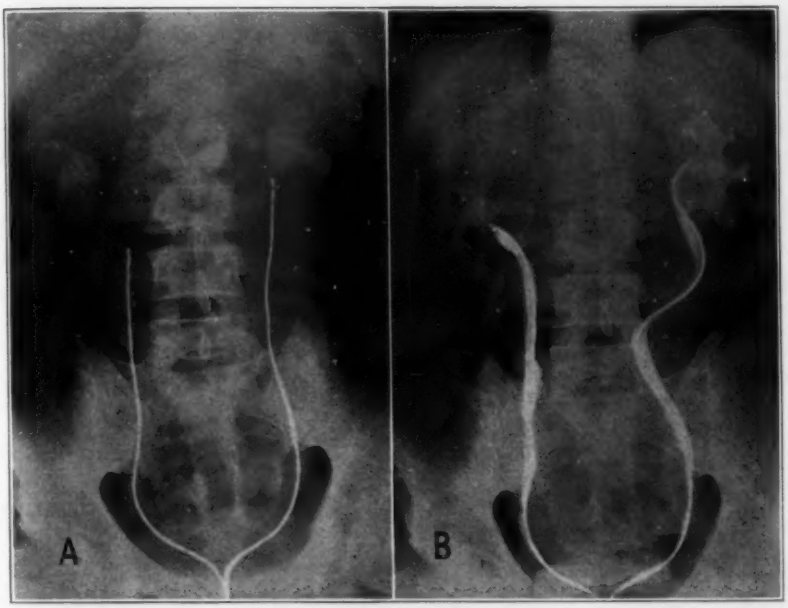

Fig. 30.—Bilateral renal calculi of the staghorn type: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, bilateral pyelogram. Nephrolithotomy was performed on the right (fig. 31).

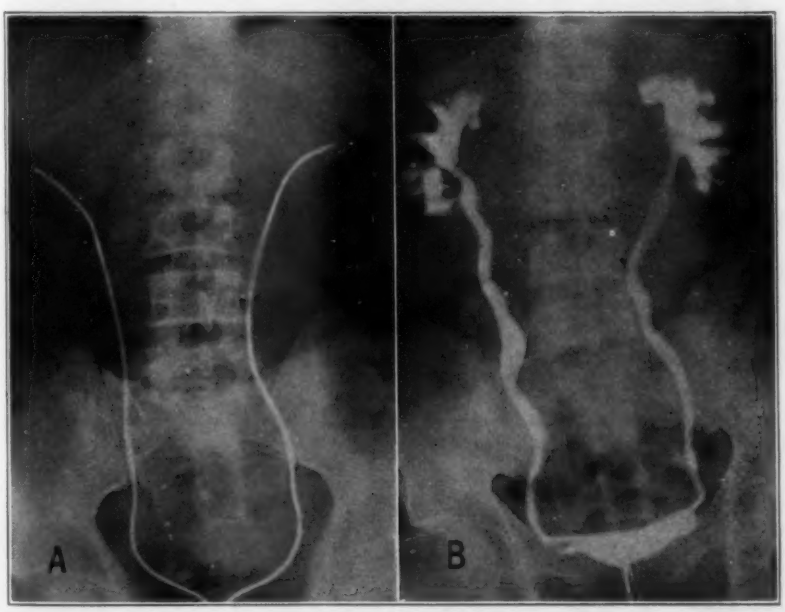

Fig. 31.—*A*, plain roentgenogram of kidney, ureter and bladder; *B*, bilateral pyeloureterogram in the case illustrated in figure 30 four years after nephrolithotomy on the right. Note that the large staghorn calculus in the left kidney has apparently disappeared spontaneously.

four years the patient had been under no dietary regimen or treatment of any kind. On his own initiative he had for one year drunk a daily cup of tea brewed from horsetail grass.[1]

CASE OF UNUSUALLY LARGE CALCULOUS PYONEPHROSIS

In calculous pyonephrosis the kidney usually increases in size, but never in my personal experience has one assumed as extensive proportions as that shown in figure 32.

It will be noted that the diaphragm on the right side is markedly raised and that the shadow of the kidney extends from the ninth rib above to the pelvic brim below. The patient was a man, aged 52, who gave a history of occasional discomfort in his right side and periodic hematuria but engaged actively in business. He did not seek medical attention until struck in the back by an

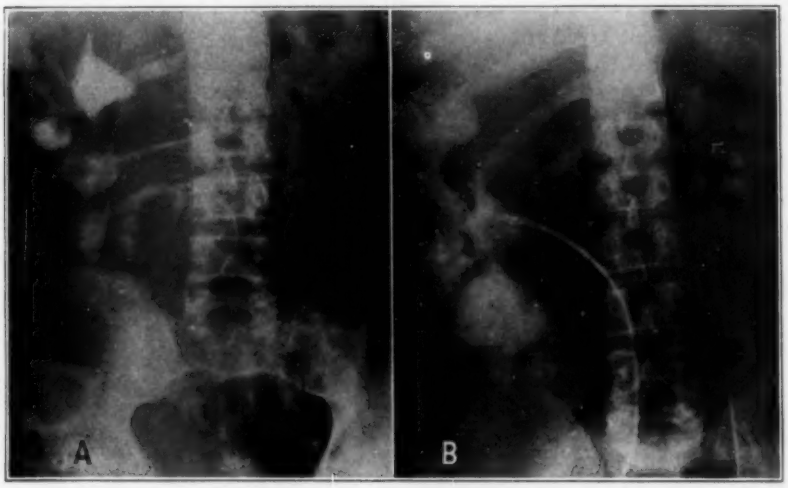

Fig. 32.—Unusually large calculous pyonephrosis: *A*, plain roentgenogram of kidney, ureter and bladder; *B*, pyelogram with incomplete filling. Note that the shadow of the kidney extends from the ninth rib above down to the pelvic brim. The patient was struck in the back by an automobile, and gross hemorrhage from this kidney resulted. An emergency nephrectomy was done to prevent fatal hemorrhage.

automobile. The accident started gross hematuria, and an emergency nephrectomy was necessary to prevent fatal hemorrhage.

SUMMARY

A series of experiences are related dealing with some of the problems encountered in the surgical treatment of renal calculi.

1. A communication from the Council on Pharmacy of the American Medical Association relative to horsetail grass ascribed to it no therapeutic value beyond a mild diuretic action.

An hydraulic maneuver of value in the removal of the small, elusive renal calculus is described.

The value of the ureteral splint and its use after pyelotomy and ureterotomy are described.

Cases are cited illustrating (*a*) choice between nephrotomy, hemi-nephrectomy and nephrectomy, (*b*) problems in the management of bilateral calculi, (*c*) cystoscopic versus operative management of ureteral stone, (*d*) gas gangrene of the wound following operation for renal stone with comment on treatment by serum and roentgen rays, (*e*) hyperparathyroidism as an etiologic factor in the formation of renal calculi, (*f*) coincident ureterolithotomy and appendectomy, (*g*) calculous pyonephrosis with anuria involving the opposite normal kidney, (*h*) phases of stone associated with renal tuberculosis, (*i*) extrarenal shadows confused with renal calculus, (*j*) spontaneous disappearance of large renal calculus and (*k*) calculous pyonephrosis of unusual proportions.

450 Sutter Street.

COMPLETE EXCISION OF THE CERVICAL GLANDS FOR REGIONAL METASTASES

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Complete excision of the glands of the neck for malignant disease consists of excision of the submental lymphatic glands; unilateral excision of the submaxillary lymphatic and salivary glands and of the occipital, the deep cervical, the paratracheal, the prelaryngeal, the superior anterior cervical, and the infrahyoid lymphatic glands, and resection of the sternocleidomastoid and the omohyoid muscle, and of the internal jugular vein (fig. 1). Descriptions of the operation by Crile and others [1] are in the literature. Each operator's technic naturally is a little different, and, as others have noted, many complete block dissections of the glands of the neck are such in name only; therefore, even at the risk of repetition, it seems well to describe mine.

The position of the patient on the operating table is flat on the back with the neck extended. The incision in the skin extends from the mastoid process of the temporal bone to a point about 2.5 cm. below the angle of the lower jaw and from this point continues parallel to the jaw to a point on the opposite side below the mental foramen. A second incision, beginning at the middle of the clavicle, meets the horizontal incision at a point midway between the angle and the symphysis of the lower jaw (fig. 1). Three flaps are raised by continuing the incision through the platysma myoides muscle and undercutting. At this time it is well to ligate, preferably with fine black silk, the small vessels which have been previously clamped. After the flaps composed of skin, subcutaneous fat and the platysma myoides muscle have been dissected back, the sternocleidomastoid muscle

1. Crile, G.: Excision of Cancer of the Head and Neck with Special Reference to the Plan of Dissection Based on One Hundred and Thirty-Two Operations, J. A. M. A. **47**:1780 (Dec. 1) 1906. Horsley, J. S.: Operations for Malignant Tumors of the Neck, Virginia M. Semi-Monthly **19**:81, 1914. Quick, D.: Radium and Surgery in Cancer of the Tongue, Brit. M. J. **2**:944, 1930. Birkett, G. E.: Radium Treatment of Buccal Carcinoma, ibid. **2**:944, 1930. Fraser, J.: Carcinoma of the Mouth and Tongue, Tr. Am. S. A. **50**:8, 1932. Myers, E. S., and Duhig, J. V.: Surgery and Pathology of Cancer of the Head and Neck, J. Cancer Research Com., Univ. Sydney **5**:30, 1933. Blair, V. P., and Brown, J. B.: The Treatment of Cancerous or Potentially Cancerous Cervical Lymph Nodes, Ann. Surg. **98**:650, 1933. Fischell, E.: Unilateral Block Resection of the Lymph Nodes of the Neck for Carcinoma, Am. J. Surg. **30**:27, 1935. Quick, D.: Metastatic Epidermoid Carcinoma of the Neck: Technical Considerations in the Combined Method of Treatment, ibid. **30**:207, 1935. Crile, G., and Kearns, J. E., Jr.: Branchial Carcinoma: Lateral Cervical Neoplasm, Surg., Gynec. & Obst. **60**:703, 1935.

is divided a short distance above the clavicle, the external jugular vein first being divided and ligated. The division of the sternocleidomastoid muscle brings into view the omohyoid muscle, which is in turn divided at the level of the division of the sternocleidomastoid. The internal jugular vein is now visible and readily accessible. The sheath of the vein is divided, and a section of the vein 4 cm. in length is mobilized. A ligature of double zero chromic catgut is placed around the vein with an aneurysm needle. A second ligature, of fine black silk, is placed just above the catgut. Both ligatures are tied, and the vein is doubly clamped above the second tied ligature and divided between the clamps, the upper clamp

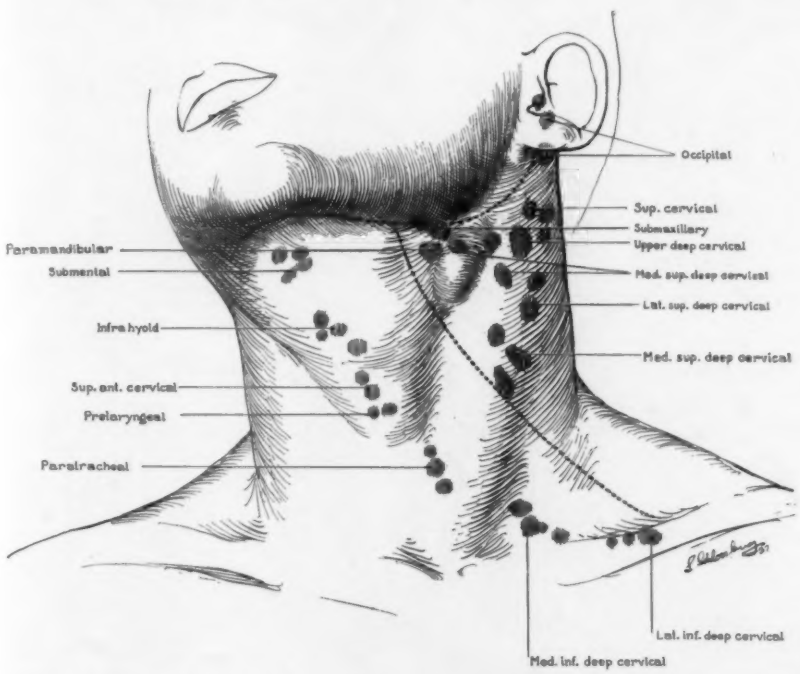

Fig. 1.—Distribution of the superficial and the deep lymphatic glands of the neck. The interrupted lines indicate the incisions in the skin.

being left in situ. I have always transfixed a third ligature to the distal stump of the vein, using a straight intestinal needle threaded with fine black silk (fig. 2).

The common carotid artery is then exposed quickly by dividing the carotid sheath (fig. 3). The carotid sheath is stripped upward, the bifurcation of the carotid artery thus being brought into view. Rather than to attempt ligation of the branches of the external carotid artery at this stage it is preferable to continue the excision along the anterior margin of the omohyoid muscle as far as the hyoid bone, clamping, dividing and ligating the superior thyroid vessels as they come into view, at the same time excising the lymphatic area anteriorly as far as the sternohyoid and the thyrohyoid muscle, removing the paratracheal, prelaryngeal, superior anterior cervical and infrahyoid lymphatic glands. The omohyoid muscle is then excised near the hyoid bone.

Next is the excision of the submental lymphatic glands, and in order to make this complete it is well to expose the periosteum of the lower jaw and to carry the excision of glands to the capsule of the submaxillary salivary gland on the opposite side. When the primary carcinoma is situated on the anterior third or the tip of the tongue or on the lower lip, it is well to study a frozen section of the lymphatic gland between the opposite submaxillary gland and the jaw, as metastasis to this gland indicates bilateral involvement. The endotherm needle

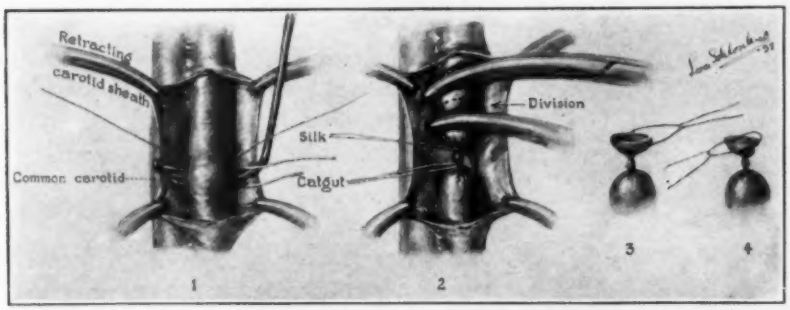

Fig. 2.—Mobilization, ligation and division of the left internal jugular vein in the lower third of the neck.

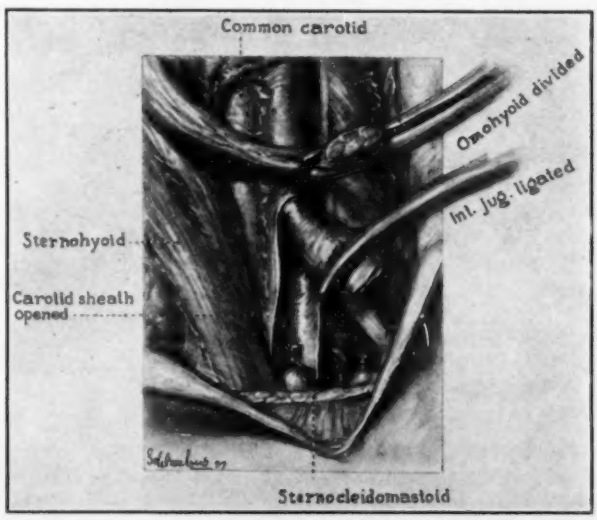

Fig. 3.—Ligation and division of the internal jugular vein completed.

may be used for the greater part of the dissection and especially for excising the submental glands and for the dissection along the lower jaw.

The facial vein and the external maxillary artery are ligated and divided, and by retraction on the mylohyoid muscle the submaxillary salivary and the sublingual glands are readily excised up to the mucous membrane of the floor of the mouth. The submental and the submaxillary glands are gently rotated posteriorly, the bifurcation of the carotid artery being thus again exposed. The branches of the external carotid artery are divided between clamps and ligated. When the primary

carcinoma involves the base or middle third of the tongue, the lymphatic glands near the bifurcation of the carotid artery are sometimes extensively involved and adherent to the carotid sheath. Even so, it is rarely necessary to ligate the external carotid artery. To facilitate the excision of this deep group of cervical glands it is often advisable to excise or divide the posterior belly of the digastric muscle.

The next procedure is the ligation and division of the artery and the vein to the parotid gland and the division of the sternocleidomastoid muscle near the mastoid process. The upper deep cervical and the occipital glands are then accessible and are removed up to the base of the skull. The internal jugular vein is clamped and ligated a short distance below the jugular foramen. It is usually safer to use an electric cautery in excising the occipital and the superior cervical

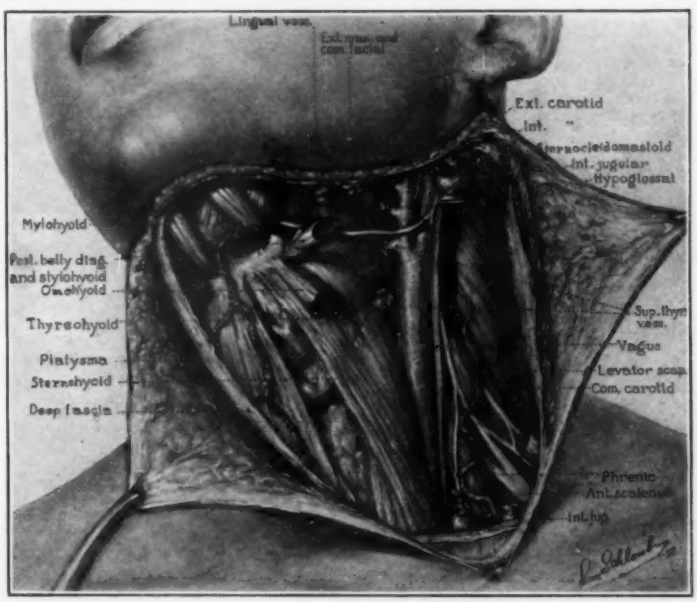

Fig. 4.—Wound after the complete block dissection of the cervical glands, showing the extent of the surgical excision.

glands if they appear grossly involved. The excision of glands is continued distally from this point, and the deep cervical glands behind the excised internal jugular vein are included in the excision. At this time procaine hydrochloride is injected into the neural branches to the scalenus muscles and the levator scapulae muscle, and the supraclavicular glands (median and lateral inferior deep cervical) are excised to the junction of the internal jugular and the subclavian vein and posteriorly and laterally to the scalenus muscles (fig. 4). The clamps controlling the small bleeding points are quickly ligated; sometimes a triangular area of skin is excised where the two incisions meet, and the wound is rapidly closed to within 2 cm. of the clavicle by approximating the skin with interrupted sutures of fine black silk. Although there is considerable serosanguineous drainage for about twenty-four hours, primary healing occurs almost without exception (fig. 5).

The credit for the conception of the mechanism of the surgical pathologic anatomy of cervical glands which are the seat of metastases from carcinoma of the head and neck belongs to Crile. Disregarding conventional methods of incomplete excision of the cervical glands for carcinoma, he conceived, employed and established on a rational basis the surgical excision of these glands. Applying the knowledge of Halsted's method of axillary dissection to the excision of the cervical glands in 1898, only four years after Halsted's first description of his operation, he reported in 1906 the results of 36 radical block dissections of the cervical glands. Crile did more than apply Halsted's method to the neck. He recognized that the sine qua non, or, as he expressed it, the "key to the situation," is the complete excision of the internal jugular vein.

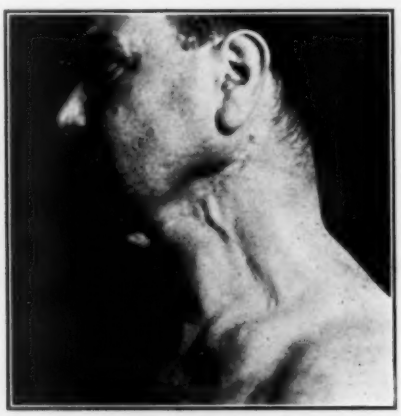

Fig. 5.—Photograph of a patient taken June 7, 1935, two years and seven months after complete excision of the cervical glands. The patient was well Sept. 11, 1937, four years and ten months after the operation. The primary lesion was a carcinoma of the tip of the tongue.

Judging from the relatively small number of papers on this subject during the thirty-one years since Crile's contribution and from personal observation and conversation with colleagues, I believe that there is a lack of enthusiasm for the operation on the part of physicians except among the small number particularly interested in this domain. In the succeeding pages facts will be presented in the hope of proving that this skepticism is not entirely warranted. Even among the workers in this field there is a difference of opinion as to whether the operation should be done as a routine whenever the primary lesion is malignant or only after evidence of metastases. It has been my practice to subject to this operation only patients in whom there was definite metastasis or presumptive evidence of metastasis confirmed by a study of a frozen section at the beginning of the complete excision.

The etiologic factors, the methods of prevention and early recognition and the treatment of the original tumor, although of prime importance, are not considered in this study. Also excluded from consideration are cases in which the operation was of less extent and those in which there was a block resection of the tongue, the floor of the mouth, the lower jaw and the glands of the neck in one stage, because the problems involved are somewhat different. A restricted operation on the cervical glands is often adequate for carcinoma of the lower lip. On the other hand, in cases of advanced carcinoma of the tongue the floor of the mouth and mucous membrane of the lower jaw or the jaw itself as well as the regional lymphatic glands may be involved. The additional extent of the involvement and the lowered resistance of the patient in such cases carry a larger operative mortality. There is, moreover, a much higher

TABLE 1.—*Metastatic Carcinoma of the Cervical Glands: Diagnosis of the Primary Lesion*

	No. of Cases
Carcinoma of the tongue	16
Carcinoma of the mucous membrane of the cheek	3
Carcinoma of the lower lip	3
Carcinoma of the mucous membrane of the lower jaw	1
Carcinoma of the mucous membrane of the antrum of the upper jaw	1
Carcinoma of the brachial cleft	3
Malignant pigmented mole	3
Carcinoma in lateral aberrant thyroid tissue	1

percentage of recurrence during the immediately succeeding and later years. I have largely given up this radical operation in cases in which the condition is advanced.

This study is confined to the consideration of cases of operable carcinoma in which there was secondary involvement of the cervical glands by metastases from a primary lesion located in the region of these glands. There were 31 cases, in all of which I operated between the years 1925 and 1937. In each instance one or more of the glands were palpable at the examination before the operation and the presence of cancer confirmed in the microscopic sections later. In table 1 are noted the diagnoses of the primary tumor in the 31 cases. Carcinoma of the tongue was present in approximately 50 per cent; carcinoma of the mucous membrane of the cheek, carcinoma of the lower lip, carcinoma of the branchial cleft and malignant pigmented moles, 10 per cent in each, and carcinoma of the mucous membrane of the antrum, carcinoma of the mucous membrane of the lower jaw or carcinoma in lateral aberrant thyroid tissue, in the remaining 10 per cent. No patient with regional metastasis from carcinoma of the larynx is recorded in this table, because such patients have not been considered suitable subjects for the operation in question.

The operative mortality in this series of 31 cases was approximately 10 per cent. Of the 3 deaths, 2 were from pneumonia, lobar pneumonia on the seventh day and bronchopneumonia on the ninth day; and 1 patient died at the end of twenty-four hours with symptoms suggesting embolism. This operative mortality of 10 per cent is far too high, and it can, I am confident, be materially reduced. In 21 of the 31 cases the operation was performed with local anesthesia (procaine hydrochloride), and in these 21 cases the operative mortality was nil. Three of the 10 patients given general anesthesia died, a mortality of 33.3 per cent among these patients. After the first death from bronchopneumonia, on the ninth day after ether drop anesthesia, in January 1926, general anesthesia was not used for more than four years. In August 1930 an operation was performed with avertin anesthesia, and death occurred in twenty-four hours with symptoms suggesting embolism. In June 1933, after anesthesia induced with avertin and ether given by rectum, bronchopneumonia developed, and the patient died of this disease in one week. Since that time (June 1933), the operations have been done with local anesthesia. I am convinced in view of this record that operations with general anesthesia involve too large a mortality to be risked, and without hesitation I recommend that the operation be done with local anesthesia if it is at all possible. The time required for this operation is about three hours, and general anesthesia for this length of time, in conjunction with this type of surgical intervention, contributes materially to postoperative complications.

After the 3 cases of postoperative death are deducted, there remain 28 cases in which the end results may be considered. Of the 16 cases in which the glands were the seat of metastatic carcinoma primary in the tongue, 13 fell within this 28. The primary tumor was located at the tip or along the lateral margin of the tongue in 13 cases and at the base in 3. In 12 of the 13 cases the tumor histologically was a low grade spinal cell carcinoma with marked differentiation toward adult epithelium and contained many pearly bodies (fig. 6). In 1 case the sections and tissue have been lost. In the 3 cases in which the primary carcinoma was at the base of the tongue the tumor histologically was a highly malignant undifferentiated transitional cell carcinoma without formation of pearly bodies. Of the 13 patients who survived the operation, 8 (61 per cent) have been alive and well for periods varying from a few months to almost eleven years (table 2). Only 1 of these 8 had the primary carcinoma on the base of the tongue (fig. 7).

Each of the 3 metastatic carcinomas of the cervical glands primary in the mucous membrane of the cheek histologically was a low grade well differentiated spinal cell carcinoma with formation of pearly bodies. All 3 patients remained well more than five years. Two of them are still well ten and a half and six years respectively after operation; 1 died

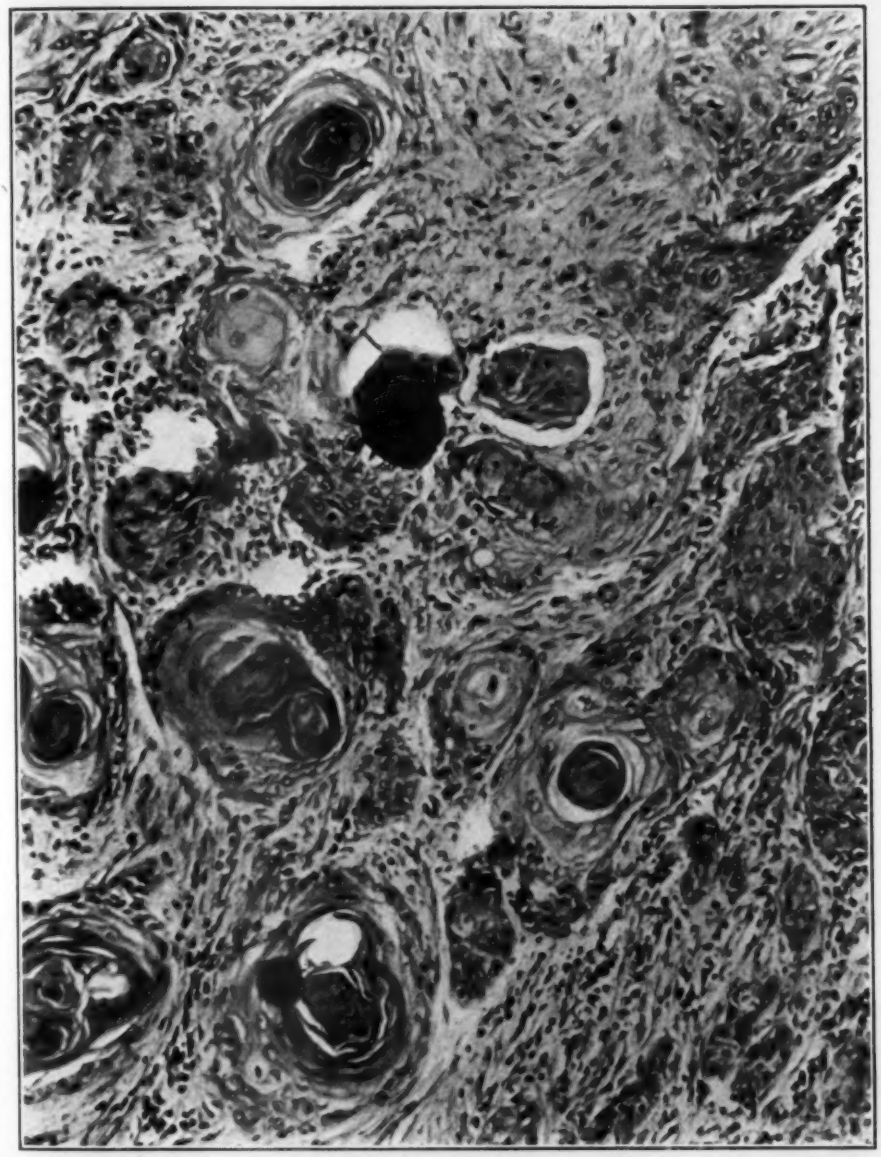

Fig. 6.—Low power photomicrograph of a cervical lymphatic gland, showing low grade spinal cell carcinoma with many pearly bodies. The complete excision of the cervical glands took place on Nov. 9, 1926. The patient was well July 10, 1937. The primary carcinoma involved the lateral margin of the middle third of the tongue.

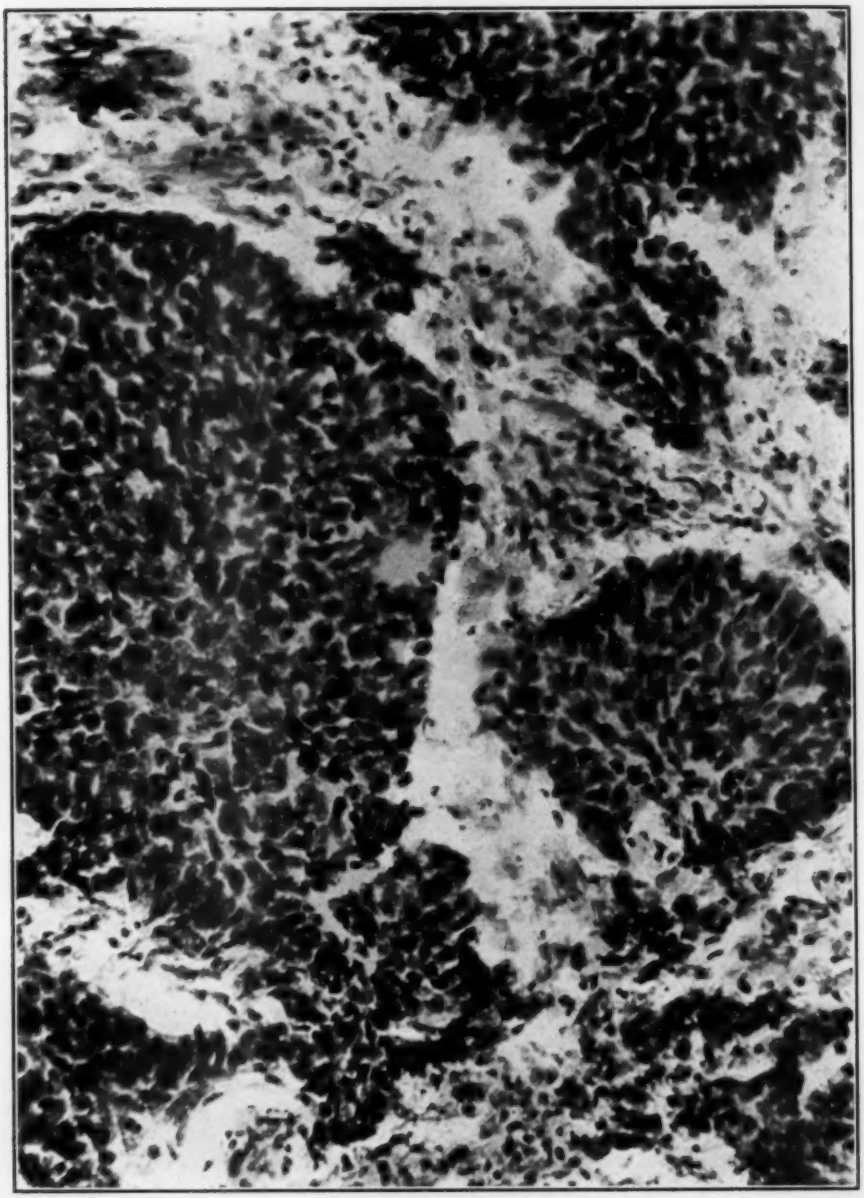

Fig. 7.—Low power photomicrograph of a cervical lymphatic gland, showing transitional cell carcinoma which characteristically occurs at the base of the tongue. In the case here illustrated there were two courses of preoperative irradiation followed by the complete excision of the cervical glands on Oct. 3, 1935. The patient was well on June 16, 1937.

eight years and five months after operation, and the autopsy revealed no evidence of recurrence or metastases (fig. 8; table 3). The complete operation was performed only 3 times for carcinoma primary in the lower lip. Two of the patients died of cancer within a few months of the operation. In 1 case, in which the histologic grading was III, involvement of the pharynx was found at operation, and in the other, in which the histologic grading was IV, the lowest supraclavicular gland was the seat of metastasis. The third patient is well and free from

TABLE 2.—*Metastatic Carcinoma of the Cervical Glands from Carcinoma of the Tongue (16 Cases)*

		No. of Cases
Postoperative death		3
Death of cancer		4
Duration of life after excision of glands: 4 mo., 5 mo., 7 mo., 1 yr. 3 mo.		
Death of pneumonia 4 days after excision of cancer of the tongue (Cervical glands excised by previous operation)		1
Patients living and well July 15, 1937		8
Duration of life since excision of glands:		
Under 1 yr.	1	
2 to 3 yr.	4	
4 to 5 yr.	1	
7 to 8 yr.	1	
11 to 12 yr.	1	

TABLE 3.—*Metastatic Carcinoma of the Cervical Glands from Carcinoma of the Mucous Membrane of the Cheek (3 Cases)*

	No. of Cases
Patient living and well 10½ yr. after operation	1
Patient living and well 6 yr. after operation	1
Death 8 yr. and 5 mo. after operation; autopsy revealed no evidence of cancer	1

TABLE 4.—*Metastatic Carcinoma of the Cervical Glands from Carcinoma of the Lower Lip (3 Cases)*

	No. of Cases
Death of cancer within a few months after operation	2
Patient living and well 3 yr. after excision of glands	1

recurrence three years after operation, even though the glands were extensively involved by metastases, and in spite of the fact that there had been a previous incomplete operation on the neck in another clinic. Histologically this tumor was graded II (table 4).

There was 1 case of carcinoma primary in the mucous membrane of the antrum of the upper jaw and 1 of carcinoma primary in the mucous membrane of the lower jaw. Histologically these tumors were graded II and III respectively. Both patients died of cancer within six months of the operation. Likewise in the 3 cases of carcinoma primary in the

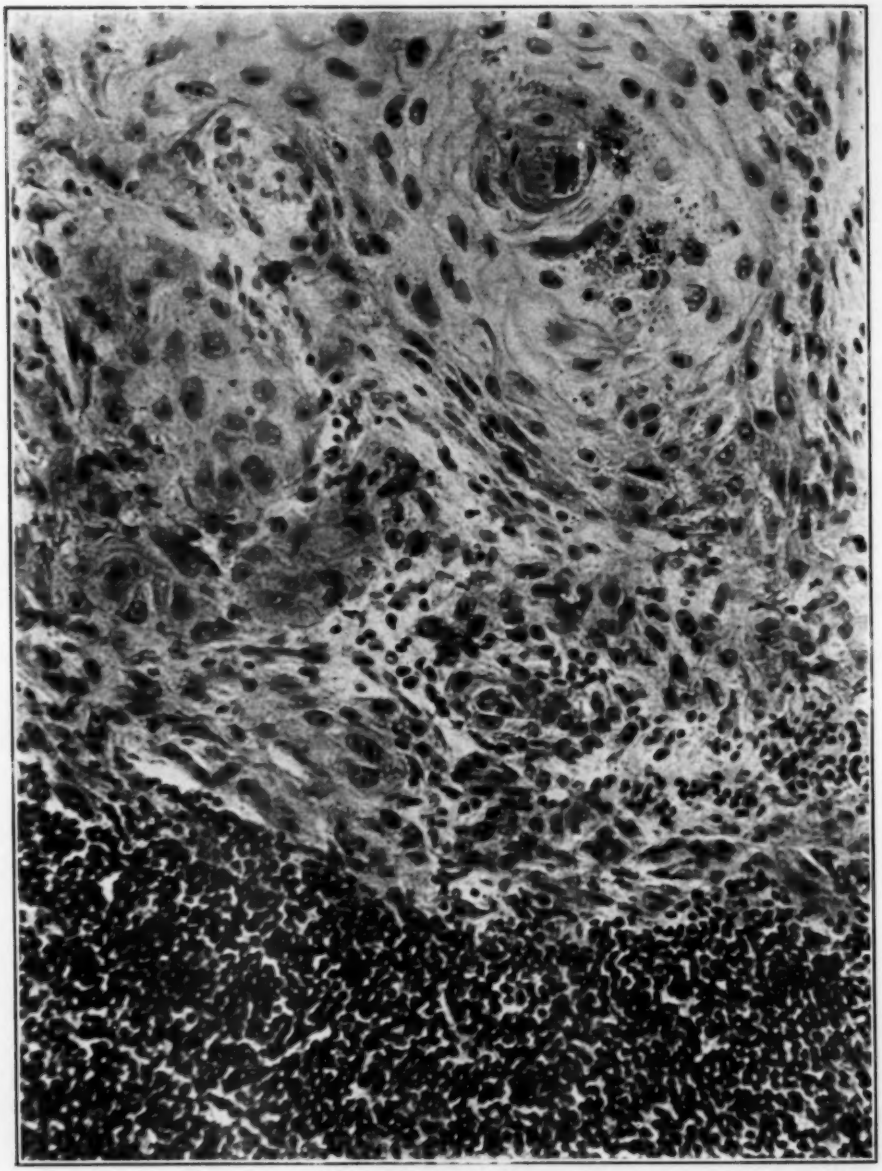

Fig. 8.—Low power photomicrograph of a cervical lymphatic gland, showing low grade spinal cell carcinoma. Complete excision of the cervical glands was done on Dec. 4, 1928. The patient died on May 9, 1937. The autopsy revealed no evidence of carcinoma. The primary carcinoma involved the mucous membrane of the cheek.

branchial cleft and in the 3 cases of metastases to cervical glands from malignant pigmented moles the termination was fatal (figs. 9 and 10). The histologic grading in the 3 cases of carcinoma of the branchial cleft was III, IV and IV, respectively (fig. 11). Tables 5 and 6 give the duration of life after operation. There is 1 patient living and well two years and eight months after the complete excision of the cervical glands for metastatic carcinoma primary in lateral aberrant thyroid tissue (figs. 12 and 13).

Fig. 9.—Photograph of a patient who had a malignant pigmented mole of the skin of the neck with extensive metastasis to the cervical glands. Preoperative interstitial radium therapy was given. Complete excision of the mole and the cervical glands was done on Jan. 6, 1933. The patient died on Oct. 30, 1933, from metastasis.

TABLE 5.—*Metastatic Carcinoma of the Cervical Glands from Carcinoma of the Branchial Cleft (3 Cases)*

Death of cancer 7 mo. after operation
Death of cancer 1 yr. 2 mo. after operation
Death of cancer 3 mo. after operation

TABLE 6.—*Metastatic Carcinoma of the Cervical Glands from a Malignant Pigmented Mole (3 Cases)*

Death of cancer 2 yr. 2 mo. after operation
Death of cancer 1 yr. 4 mo. after operation
Death of cancer 10 mo. after operation

Just what part irradiation ultimately will take in the handling of these cases is difficult to establish at this time. In table 8 is a summary of the irradiation therapy employed in this series. From the study of this relatively small group of cases in which the primary lesion and consequently the metastatic glands represent a number of different patho-

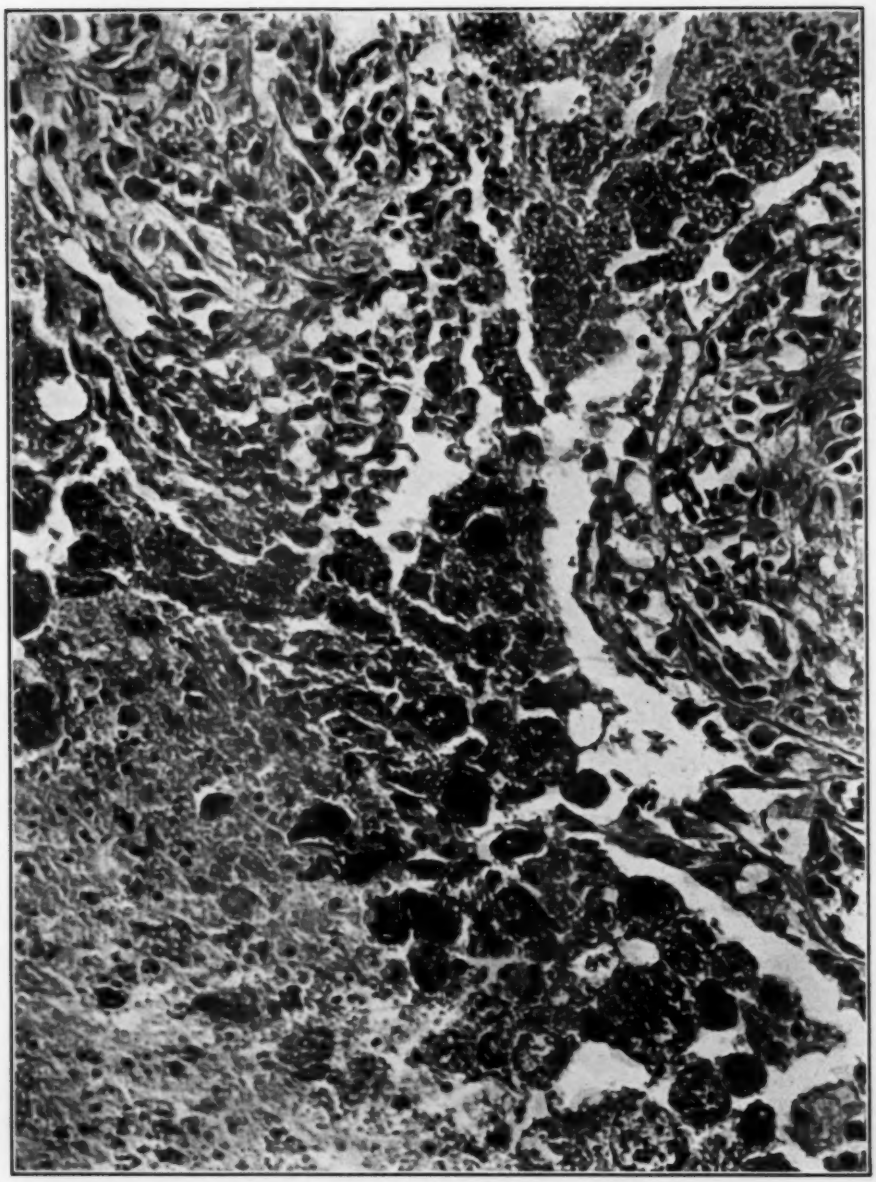

Fig. 10.—Low power photomicrograph of a cervical lymphatic gland, the seat of metastasis from a malignant pigmented mole of the skin of the neck. Preoperative external roentgen irradiation was employed. Complete excision of the tumor and the cervical glands was done on Jan. 5, 1933. The patient died in May, 1934, of metastasis to the brain.

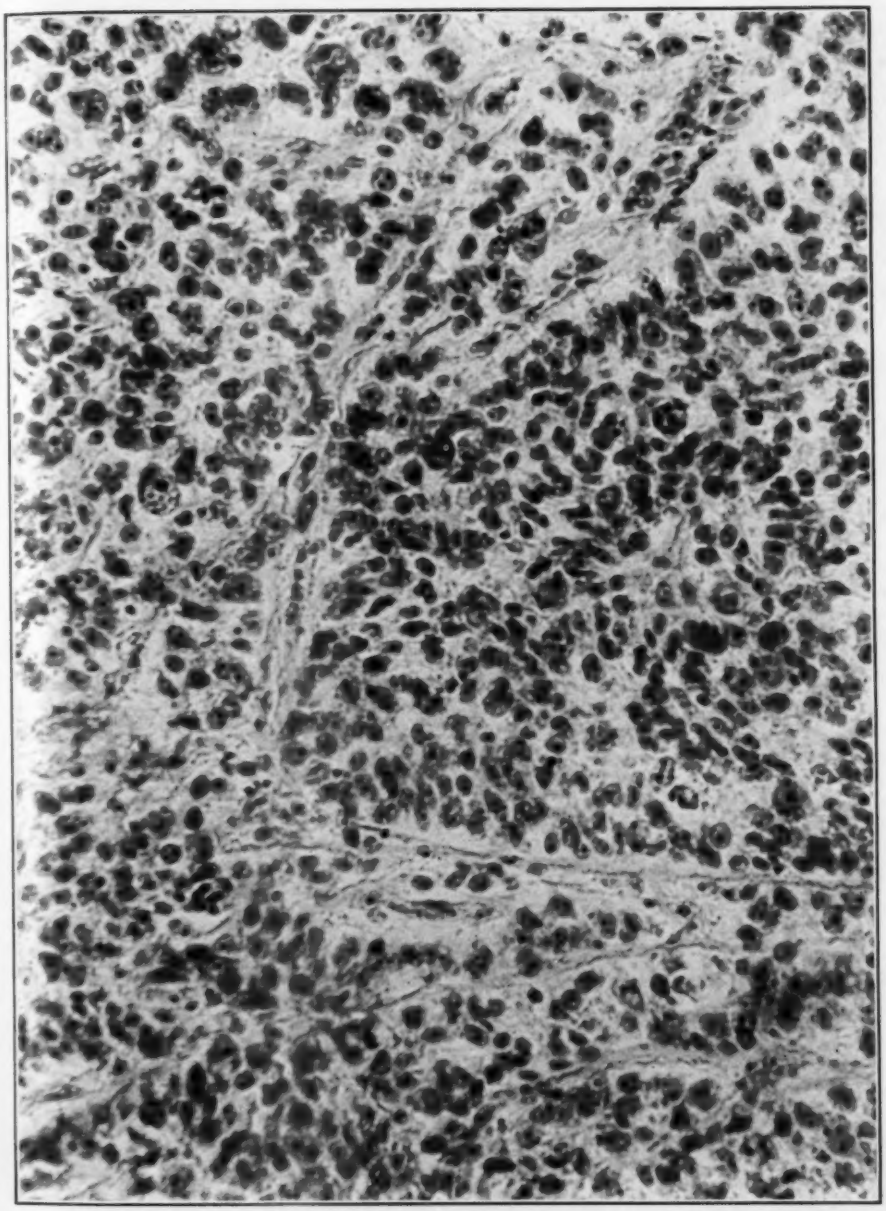

Fig. 11.—Low power photomicrograph of a cervical gland, showing grade IV spinal cell carcinoma primary in the branchial cleft. Complete excision of the cervical glands was done on Aug. 10, 1925. The patient died of cancer on Oct. 11, 1926.

TABLE 7.—*Metastatic Carcinoma of the Cervical Glands*

	No. of Cases
Primary lesion in the mucous membrane of the upper jaw Death of cancer 4 mo. after operation	1
Primary lesion in the mucous membrane of the lower jaw Death of cancer a few months after operation	1
Primary lesion carcinoma in lateral aberrant thyroid tissue Patient well 2 yr. 8 mo. after operation	1

TABLE 8.—*Metastatic Carcinoma of the Cervical Glands: Therapy by Irradiation*

	No. of Cases
A. Primary lesion in the tongue—16 cases	
Preoperative irradiation (roentgen) of the cervical glands	8
Well 1 to 2½ yr. after operation: 4	
Death of cancer: 2	
(5 mo. after operation; 1 yr. 3 mo. after operation)	
Postoperative death: 2	
Postoperative irradiation (roentgen) of the cervical glands	2
Well 7½ yr. after operation: 1	
Death 3½ mo. after operation: 1	
Postoperative irradiation (radium) of the cervical gland on the opposite side (Patient well 4 yr. 10 mo. after operation)	1
No irradiation	5
Patient well: 2	
(11 yr. 6 mo. after operation; 2½ mo. after operation)	
Death: 3	
(7 days after operation of pneumonia; 5 days after excision of cancer of the tongue, of pneumonia; 7 months after operation, of cancer)	
B. Primary lesion in the mucous membrane of the cheek—3 cases	
No irradiation	3
Patient well: 2	
(8 yr. 9 mo. after operation; 6 yr. after operation)	
Death: 1	
(8 yr. 5 mo. after operation; autopsy revealed no evidence of recurrence or metastasis)	
C. Primary lesion in the lower lip—3 cases	
Preoperative irradiation (roentgen) (Patient well 3 yr. after operation)	1
No irradiation (Death a few months after operation; death 4 mo. after operation)	2
D. Primary lesion in the branchial cleft—3 cases	
Preoperative irradiation (roentgen) (Death 4 mo. after operation)	1
No irradiation (Death 1 yr. 5 mo. after operation; death 7 mo. after operation)	2
E. Primary lesion malignant pigmented mole—3 cases	
Preoperative irradiation (radium) (Death 9 mo. after operation; death 1 yr. 4 mo. after operation)	2
Postoperative irradiation (roentgen) (Death 2 yr. 2 mo. after operation)	1
F. Primary lesion in other locations—3 cases	
Primary lesion in the mucous membrane of the upper jaw No irradiation (Death 4 mo. after operation)	1
Primary lesion in the mucous membrane of the lower jaw Postoperative irradiation (roentgen) (Death a few months after operation)	1
Primary lesion carcinoma in lateral aberrant thyroid tissue Preoperative irradiation (radium) (Patient living and well 2 yr. 8 mo. after operation)	1

logic processes, only a few conclusions seem justified. While it is impossible without producing irreparable damage to deliver by external irradiation a lethal dose of roentgen rays or radium to any but a very ray-sensitive tumor, there seems to be no danger in delaying the operation for a course of preoperative irradiation when the glands are not palpable, or for the purpose of testing the sensitivity of the tumor to rays when they are palpable. In 13 instances, because of metastases or because the microscopic picture was such as to suggest the probability of metastases, the glands were irradiated and then excised or excised later when they became palpable.

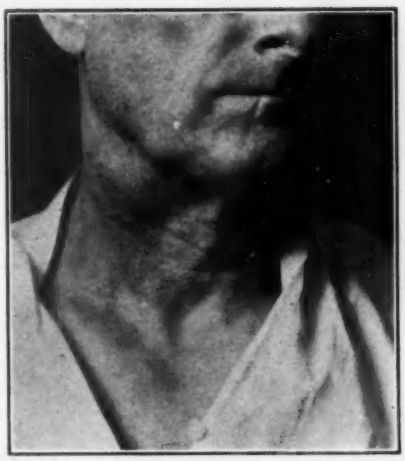

Fig. 12.—Photograph of a patient on Nov. 5, 1934, showing a tumor in the submaxillary area of the neck. The scar on the lower lip is from the excision of a benign wart fifteen years before. There was preoperative radium treatment. The cervical glands were completely excised on Nov. 22, 1934. The patient was well on July 9, 1937. For the microscopic appearance of the tumor, see figure 13.

Occasionally after irradiation there was a diminution in the size of the palpable gland or glands, but in only 2 instances was there complete disappearance of a metastatic cervical gland under irradiation, and in 1 of these there was no conclusive evidence that the gland was actually cancer. In the other a gland that was the seat of metastasis from carcinoma of the base of the tongue disappeared completely after a course of external irradiation but recurred in six months. A second course of irradiation was given without any change in the size of the gland, and after the second course of irradiation the glands were completely excised (fig. 7). In the former, a case in which there was no preoperative irradiation, a nodule developed over the right side of the larynx four months after a complete operation on the left side. In a few days this

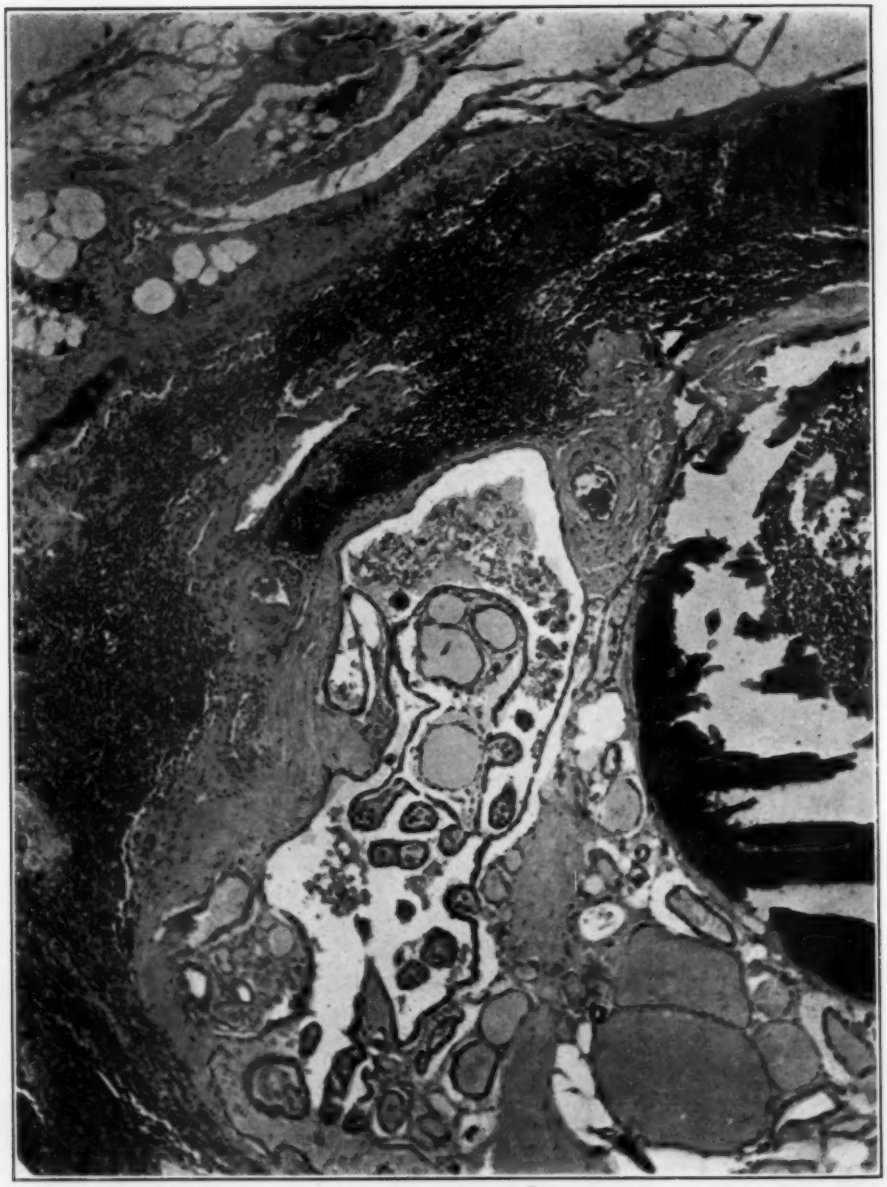

Fig. 13.—Low power photomicrograph of a cervical lymphatic gland, showing papillary adenocarcinoma primary in lateral aberrant thyroid tissue. Figure 12 shows a photograph of the patient before operation.

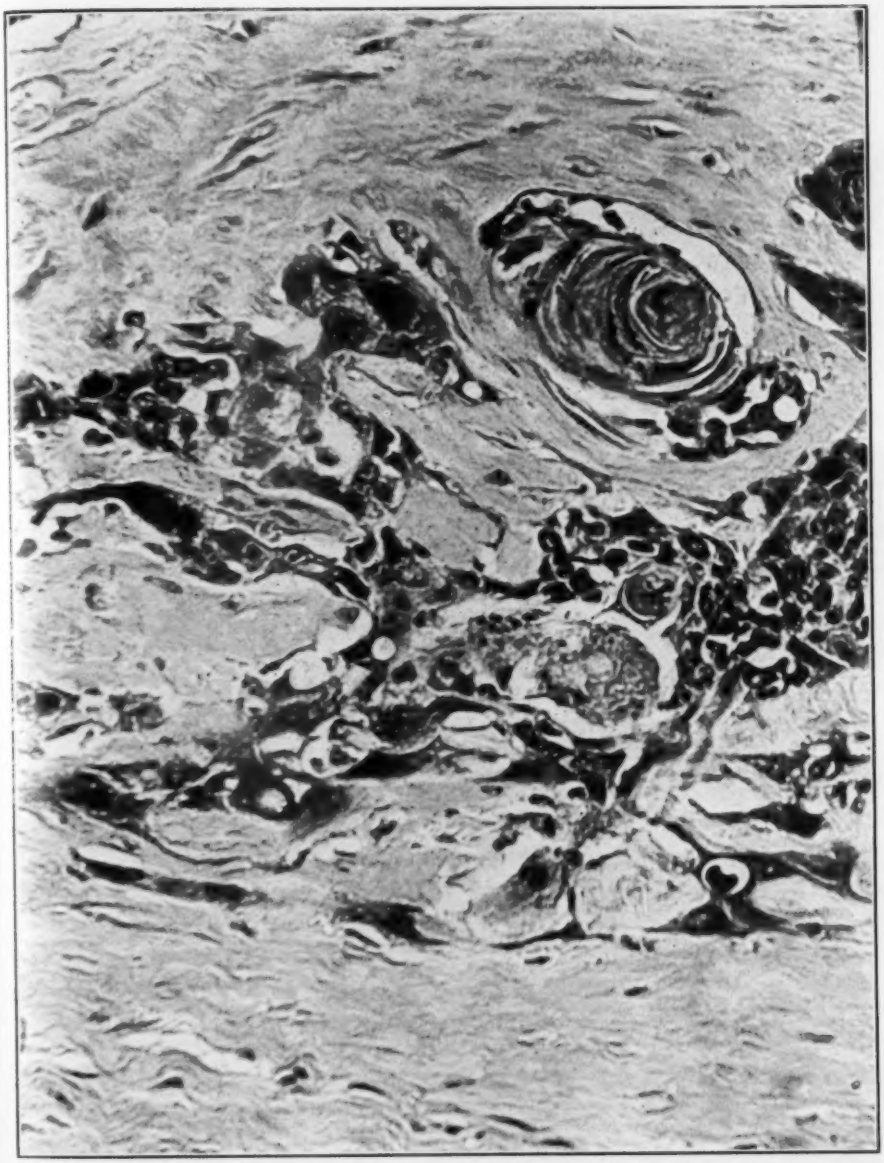

Fig. 14.—Low power photomicrograph of the capsule of a cervical lymphatic gland, showing residual carcinoma. There were two courses of preoperative roentgen irradiation. The cervical glands were completely excised on Jan. 3, 1935. The patient was well on April 5, 1937. The primary carcinoma involved the middle third of the tongue.

nodule reached 2.5 cm. in diameter and appeared as though it were going to burst. Two radon seeds were introduced into the mass, after which the lesion, apparently carcinoma, rapidly disappeared and has not recurred during the four years and four months since the irradiation (fig. 5).

In some instances there were distinct changes in the microscopic pathologic condition of the glands in cases of low grade well differentiated carcinoma with pearly bodies, which in all likelihood were due to the irradiation. Granting that cervical glands that are sites of metastases from carcinoma of the tongue sometimes undergo extensive necrosis and cystic degeneration, I have never observed in the non-irradiated gland the changes which occurred after irradiation in 1 of these cases. In this instance the gland resembled an atheromatous cyst, with a capsule like the wall of a cyst and with contents soft and cheese-like. The only evidence of residual carcinoma histologically consisted of a few nests of squamous cells firmly confined in a much thickened capsule, although the cystic mass was about 4 cm. in diameter (fig. 14).

CONCLUSION

Enough time has elapsed since operation in a sufficient number of cases to allow the statement that many patients who had carcinoma of the cervical glands are now well. Had they not been subjected to the complete excision of these glands, with or without irradiation, they would not be living and free from recurrence. This fact is ample evidence to warrant the conclusion that this type of surgical intervention, alone or combined with irradiation, offers sufficient hope for the cure of patients with regional metastases from carcinoma in the cervical glands to justify its adoption in all cases in which the condition is operable.

PSEUDOULCERS OF THE DUODENUM OF THE NORMAL DOG

INCLUDING A STUDY OF THE INCIDENCE OF INTESTINAL ULCERS IN THE NORMAL DOG

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Considerable work has been done on the production of ulcers in the intestinal tract of the dog. The incidence of experimentally produced ulcers varies with the type of operative procedure employed. The Exalto and the Mann Williamson technic give the highest percentages of positive results. A detailed description of these methods was given in a previous report. The relative immunity of the duodenum to formation of ulcer by experimental methods is therein commented on.

The existence of ulcers in the gastrointestinal tract of the normal laboratory animal which has not been operated on is of rare occurrence; no particular attention is called to this in the literature. We determined, therefore, to make observations of the entire gastrointestinal tracts of apparently normal dogs and to determine the incidence of intestinal ulcers in these animals.

We have recently reported work from this laboratory on the production of experimental duodenal ulcers in the dog and have called attention to the occurrence of circular punched-out depressions in the duodenum, which at first glance appear to be ulcers. It seems that little or no attention has been paid to these findings by the various investigators doing experimental work with the gastrointestinal tract of the dog. This is noteworthy because such depressions may easily on gross inspection be erroneously diagnosed and may have been mistaken for ulcers by workers in this field.

It is not our object to go into elaborate detail as to the normal anatomic and histologic picture of the duodenum of the dog. Our attention was confined to these ulcer-like depressions which are especially abundant in the duodenum and which are apparently a usual finding. We wished also to determine the incidence of ulcer in the intestinal tract of the normal dog which has not undergone an opera-

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tion. There is no reference in the clinical literature [1] (so far as it has been available to us) to these pseudoulcerous depressions.

Chauveau [1a] and more recently Bradley [2] in their descriptions of the duodenum of the dog made no mention of such depressions. Sisson [3] in his book "The Anatomy of Domestic Animals," in describing the intestinal tract of the dog, stated:

> Aggregated lymph nodules or Peyer's Patches are numerous (about 20 in number in young subjects) and begin in the duodenum. They are usually elliptical in outline and the last one is band-like and reaches the end of the ileum and is four to sixteen inches long.

In describing the histologic picture of the intestinal tract of man, Jordan [4] stated:

> Above the level of the ileum the largest collection of lymph tissue in the intestinal mucosa occurs in the duodenum where there are extensive infiltrations of dense lymphoid tissue, many of which contain typical nodules with germinal centers. These masses of lymphoid tissue are penetrated by the ducts of duodenal glands whose secretion forms a bed upon which the lymphoid tissue rests. The duodenal "patches" differ slightly from those in the ileum in that they form a more confluent mass with relatively few nodules. They also possess a more diffuse character, are more deeply situated and are therefore covered by the corium of the mucosa which contains both intestinal glands and villi.

MATERIALS AND METHODS

The animals used in this study were taken from among those used in the department of physiology for experimental purposes. They had not been subjected to any type of experimentation that might in any manner affect the gastrointestinal tract. They were taken at random, irrespective of age, weight or breed; only those animals that appeared healthy, however, were used. These animals were killed and the entire gastrointestinal tract was removed and was examined as follows:

1. Observation of the entire gastrointestinal tract in situ was made.

2. The entire tract was opened and the gross appearance and internal structure observed with the following points especially in mind:

   a. Number, size, location and appearance of ulcers, if any;

   b. Number, size, location and appearance of depressions, or pseudoulcers.

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1. Ochsner, A. J.: Further Observations on the Anatomy of Duodenum, Am. J. M. Sc. **132**:1, 1906.

1a. Chauveau, A.: Comparative Anatomy of the Domesticated Animals, London, J. & A. Churchill, 1891.

2. Bradley, O. C.: Topographical Anatomy of the Dog, New York, The Macmillan Company, 1935.

3. Sisson, S.: Anatomy of Domestic Animals, Philadelphia, W. B. Saunders Company, 1921.

4. Jordan, H. E.: Textbook of Histology, ed. 6, New York, D. Appleton-Century Company, Inc., 1934.

3. Photographs of the depressions in the gross specimen were taken. Microscopic sections of the depressions were also made.

4. Photographs of the gross specimen and microscopic sections of the Peyer patches in the ileum were made.

ANATOMIC FINDINGS

We have examined the entire gastrointestinal tracts of over 75 dogs without finding evidence of ulcers in any. The animals were all apparently healthy except that 10 had worms. Only 55 of the dogs, however, have been considered in this study. The type record for findings with data is shown below:

Date 4/22/37

Dog 10 Breed—Collie Wt.—18 Kg. Sex—Female

Appearance—Healthy; slight conjunctivitis

Miscellaneous information—Killed with ether

Stomach—No ulcers

Duodenum:

Gross external appearance—Nine raised circular pale patches measuring 3 to 12 mm. in diameter, along the antimesenteric border

Gross internal appearance—Depressed area corresponding to those seen externally, arranged in linear alinement

Depressed areas—Total number, 9; size, 3 to 10 mm. in diameter; location, antimesenteric border mostly; appearance, circular; punched-out; rolled edges; base covered with normal mucosa

Ulcers—Total number, none; size, none; location, none; description, none

Jejunum

Depressed areas—Total number, 2; size, 2 to 4 mm. in diameter; location proximal

Antimesenteric border—Circular; punched-out; covered with normal mucosa

Ulcers—None

Ileum

Depressions—None

Ulcers—None

Colon

Depressions—None

Ulcers—None

Microscopic Section—Depression in mid-duodenum; section made; stained with hematoxylin and eosin

For the 55 animals studied there was no evidence of ulcers in the stomach, the duodenum or the small or the large intestine. There were noted, however, in the duodenum, circular punched-out depressions along the mucosal surface, measuring from 3 to 15 mm. in diameter and varying in number from three to ten. These depressions corresponded for the most part with similar raised circular areas seen on the serosal surface of the duodenum, which were paler than the surrounding

mucosa. The bile and pancreatic ducts usually opened into the duodenum about ¾ to 1½ inches (2 to 4 cm.) from the pylorus.

These depressions were entirely confined to the duodenum; in young animals, however, they were also seen in the proximal part of the jejunum. In 1 subject about 6 weeks old the depressions in the duode-

Fig. 1.—Photograph of the duodenum of a normal dog. Note the circular punched-out depressions in linear arrangement. These closely resemble ulcers.

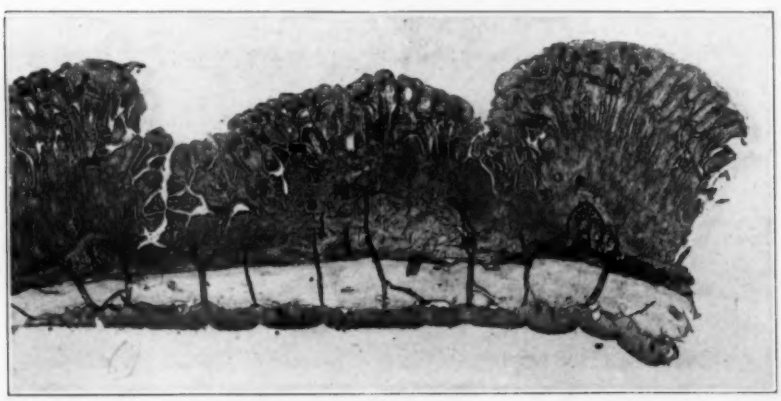

Fig. 2.—Section from the upper part of the duodenum of a normal dog, showing punched-out depressions. Note the thinness of the mucosa at this site and also the absence of the crypts of Lieberkühn. There is some lymphocytic infiltration of the submucosa and the tunica propria. Note the tendency toward reduplication of the muscularis mucosae and the submucosa at the periphery of the depression.

num were numerous and were present even down to the proximal part of the ileum. The depressions gradually became more shallow from the duodenum to the ileum, until they became raised above the mucosal surface as true Peyer patches, as seen in the lower portion of the ileum.

These depressions as they were seen grossly along the mucosal surface of the duodenum appeared much like punched-out ulcers, but on close inspection it was noted that the edges were not undermined but were rather rolled and smooth and that the base and the entire surface were covered with normal intact mucosa. The depressions did not correspond to the valvulae conniventes seen in the human duodenum;

Fig. 3.—Section through the lower part of the duodenum, showing another depression. This does not show the marked thinness of the mucosa at the site of the depression as does figure 2. It does, however, show the out-pouching of the serosa at this site and also the reduplication of the muscularis mucosae and the submucosa at the periphery of the depression. Note also the three small areas of lymphocytic aggregation in the submucosa.

Fig. 4.—Lower third of the ileum of a normal dog, showing typical Peyer patches. Compare this with figure 1, which shows depressions of the duodenum.

in fact, true valvulae conniventes were not observed at all in the dog. Five per cent of the duodenums showed smooth mucosa grossly. The depressions were present in 50 of the 55 dogs considered or 90.8 per cent.

Figure 1 is a photograph showing the duodenal mucosa of a normal animal which has not been operated on. Note the punched-out depressions in linear arrangement. At first glance they appear to be ulcers.

Figure 2 is a low power photomicrograph of a section through one of these depressions, stained with hematoxylin and eosin. This section is taken through the upper third of the duodenum and shows the thickness of the wall and the absence of Brunner glands at this particular

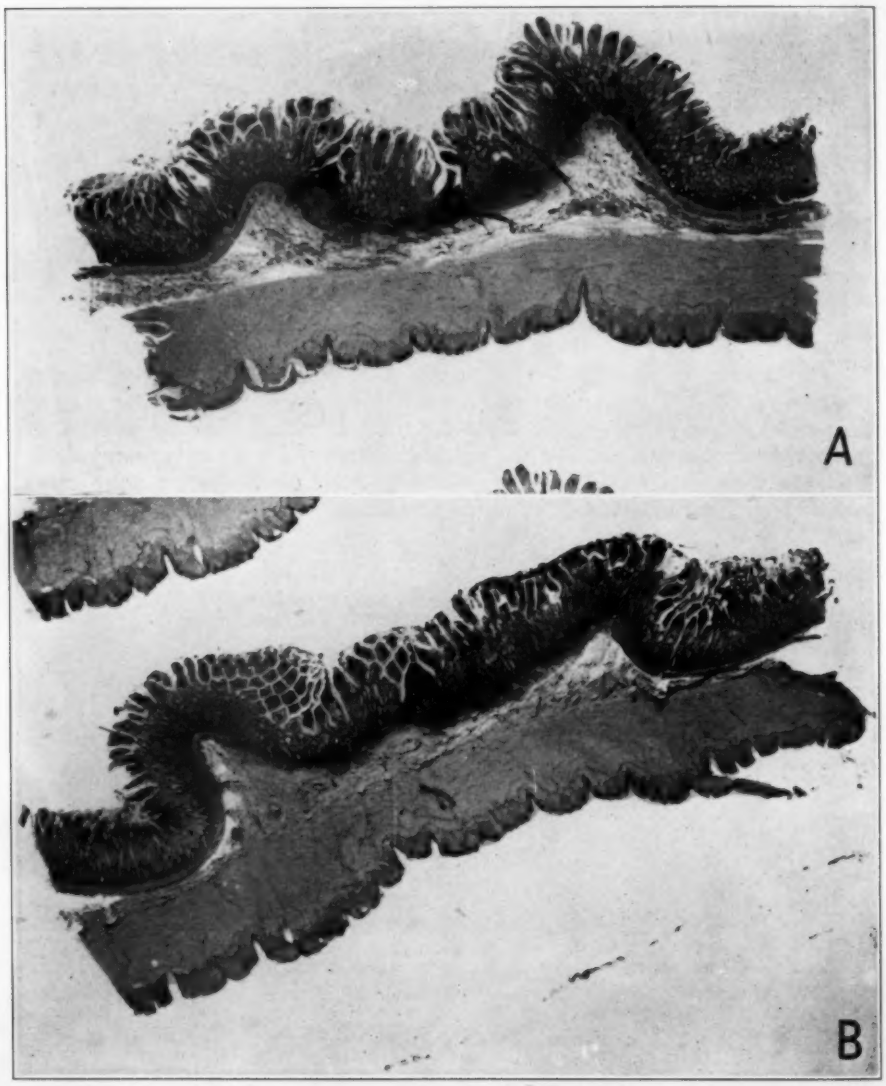

Fig. 5.—*A*, section through a Peyer patch removed from the lower part of the ileum of a normal dog. Note the presence of the lymph nodules with typical germinal centers, the uniform thickness of the mucosa throughout and the projection of the mucosa at this site into the lumen of the bowel. *B*, another section through a Peyer patch removed from the lower part of the ileum of a normal dog. Compare with figure 5 *A* above.

level. Brunner glands in the duodenum of the dog are present only for a very short distance from the pylorus. The mucosa in this region is intact throughout the entire section despite the definite depression. The depression is due to a thinning out of the mucosa at this site. The crypts of Lieberkühn beneath the depression are shallow or appear to be lacking entirely. The submucosa and the corium of the tunica propria showed some lymphocytic infiltration, with a few small nodules. The lymphocytic infiltration is not dense or diffuse like that seen in a typical Peyer patch. There is in this section a tendency for reduplication of the submucosa and the muscularis mucosae, but the muscular and serosal coats are not disturbed.

Figure 3 shows a section through a depression removed from the duodenum of another animal, taken through the lower third. This section is practically identical with the one seen in figure 1. In this

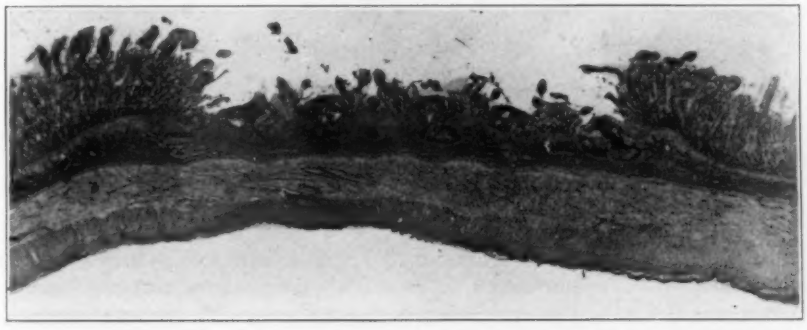

Fig. 6.—Microscopic section through an ulcer from the middle third of the duodenum. Note the absence of Brunner glands at this level.

section, however, the depression and reduplication are more marked, and there is a definite out-pouching of the serosal coat. It is to be noted that although there is some lymphocytic aggregation it does not seem to be very marked. Many sections revealed absence of any form of lymphocytic cell accumulation. We should say, however, that these areas may correspond to, but are not identical with, the Peyer patches. The depressions certainly do not show marked lymphocytic aggregation in the mucosa and submucosa with eversion of the mucosa and projection of the "path" into the lumen of the bowel, as does a typical Peyer patch.

Figure 4 is a gross photograph of a typical Peyer patch, removed from the ileum for comparison. The elevated character of the agminated lymphatic follicles of the Peyer patch is readily appreciated.

In figure 5 the microscopic picture of the Peyer patch illustrates projection into the intestinal lumen, with rich accumulation of lymphatic cells about the germinal centers.

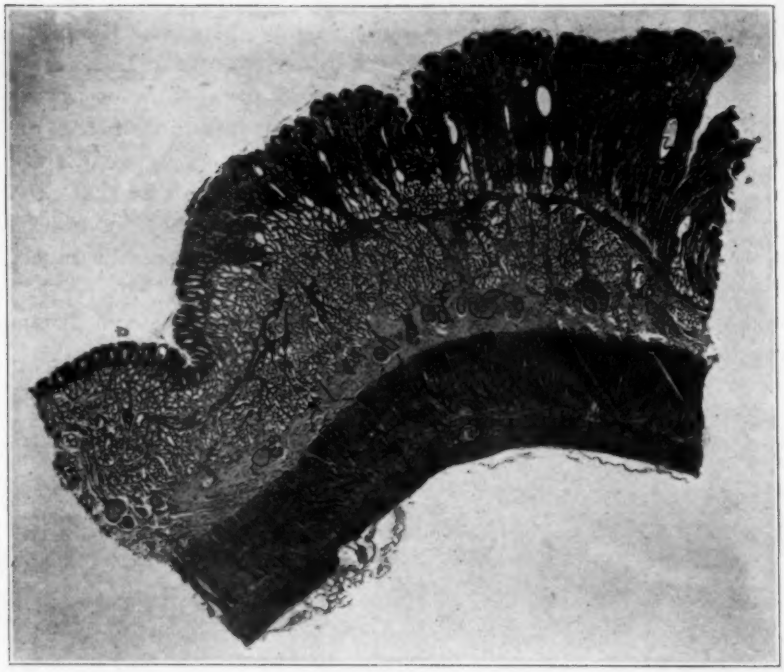

Fig. 7.—Section through the upper part of a normal duodenum close to the pylorus. Note the thickness of the wall, the presence of Brunner glands at this site and the rather scant evidence of lymphocytes.

Fig. 8.—Gross photograph showing ulcers in the duodenum, experimentally produced.[5]

Figure 6 shows a duodenal ulcer in microscopic section produced by an operative procedure mentioned elsewhere.[5] Figure 7 shows a microscopic section of normal duodenum close to the pylorus. Note the presence of Brunner's glands at this site and the rather scant evidence of lymphocytes.

COMMENT

The depressions mentioned were present in most of the animals examined. They were not localized areas of peristalsis, as they might first appear when seen on the serosal surface in the living animal. They were due to a definite out-pouching of the intestinal wall at the site, with a thinning of the mucosa. It is possible, as we have already mentioned,[5] that such areas may be the site of ulcer formation (experimental) in the duodenum. This, however, we have not been able to prove.

We call attention to this observation because it might prove confusing to one doing experimental work on the gastrointestinal tract. This indicates necessity for microscopic section in the study of suspicious areas before one can definitely determine whether these are ulcers or not.

SUMMARY AND CONCLUSIONS

A study of the gastrointestinal tract of the normal dog is presented; special emphasis is placed on the duodenum. Particular attention is directed to the incidence of ulcers of the intestinal tract in animals used for experimental work. Attention is called also to the occurrence of punched-out depressions on the mucosal lining of the duodenum, which is an apparently normal condition. The following conclusions are offered:

1. No ulcers were found in the intestinal tract of any of the animals studied.

2. The incidence of ulcer-like depressions in the duodenum of the normal dog is 90.8 per cent.

3. These depressions probably correspond to, but are not identical with, Peyer patches.

4. It is possible that these depressions may be confused with ulcers and should be considered as a site of possible ulcer formation by workers attempting to produce experimental ulcers in the dog.

5. Microscopic evidence is necessary before decision is made as to the presence of ulceration.

5. Volini, I. F.; Widenhorn, H. L., and Finlayson, B.: Experimental Duodenal Ulcer, Surg., Gynec. & Obst. **65**:159 (Aug.) 1937.

PERIANAL CYSTS OF VESTIGIAL ORIGIN

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The caudal end of the body is a frequent site for the development of cysts, tumors and fistulas of vestigial origin. Here numerous anlages appear almost simultaneously, some of which proceed through a complex series of changes to form the final organ or system while others develop to a certain stage only to regress and be resorbed. Disturbances in the developmental sequence, arrested development, heterotopia and failure of regression may be factors contributing to the formation of anomalous conditions. The persistence of caudal vestiges and the possibility of their subsequent development into tumors and cysts have been widely acknowledged. These lesions are regarded with much interest not only by the surgeon and the pathologist but also by the embryologist, because of the links which they provide in establishing the chain of evidence concerning the fate of certain embryonal structures.

The present communication will review the embryology of the caudal end of the body in general and the development and regression of anterior sacral and perianal embryonal vestiges formed from a single germ layer in particular. The relation of such vestiges to cysts and tumors of this region will also be discussed. Cases illustrating some of these lesions will be reported.

The human embryo posesses a true tail, which reaches its maximum development at about the 8 mm. stage.[1] From this stage progressive reduction occurs, until the tail has completely disappeared by the time the embryo has grown to about 30 to 35 mm. During this time the several systems which occupy the caudal end of the embryo have appeared and have undergone complex developmental processes. The primitive intestinal tract, the urogenital tract, the early skeletal system, the vascular channels and the neural tube are all involved in the formation of this region.

From the College of Physicians and Surgeons, Columbia University, and the Department of Surgery, the Presbyterian Hospital.

1. Kunitomo, K.: Development and Reduction of the Tail and of the Caudal End of the Spinal Cord, Contrib. Embryol. (no. 26) **8**:163, 1918.

Early in the development of the embryo (14 to 18 days) a linear ridge, the "primitive streak," appears in the posterior part of the oval embryonic area, which marks the zone of contact of the ectomesodermal vesicle and the entodermal vesicle. This is followed by the appearance of a groove, the "primitive groove," on the surface of the primitive streak. The anterior part of the groove, which extends only about half the distance toward the anterior margin of the embryonic area, terminates in Hensen's node. As the groove develops it forms a perforation which passes through the anterior end of the streak and the underlying entoderm into the entoblastic cavity. This is the blastoporic, or neurenteric, canal (fig. 1 *A*). This communication is highly transitory in man and disappears before the neural groove is converted into a closed tube.

Eternod [2] described an embryo of 2.1 mm. which showed the beginnings of these structures very well. This was one of the few human embryos in which the neurenteric canal has been observed (fig. 1 *B*).

In this stage, one finds that (1) the neural tube has not yet closed; (2) the notochord and the notochordal canal are present; (3) the neurenteric canal forms a communication between the primitive medullary and intestinal canals; (4) the primitive streak is beginning to form, and (5) the caudal intestine is demarcated by the cloacal membrane.

The medullary tube, which arises by a process of invagination from the neural plate, a derivative of the ectoderm, originally extends the full length of the embryo, including the tail. Before the formation of the medullary tube is complete, however, the neurenteric canal develops just caudad to the terminal portion of the notochord. Presumably the neurenteric canal is composed of tissue derived from both the neural tube and the primitive intestine and should it persist would be found opening caudad to the filum terminale in the coccygeal region.[3] The neurenteric canal, however, has never been studied in detail because of its extremely early development and its brief existence. No genuine vestiges or cysts arising from this structure have been described (Peyron [4]).

The caudal end of the neural tube, together with the caudal end of the notochord and the caudal intestine, extends to the ventral side of the tail and fuses with a solid mass of mesodermal cells, forming the so-called "residual mass." At several points the central canal of the neural tube becomes narrowed, and the canal gradually becomes

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2. Eternod, A. C. F.: Premiers stades de la circulation sanguine dans l'oeuf et l'embryon humains, Anat. Anz. **15**:181, 1898.

3. Lewis, F. T., in Keibel, F., and Mall, F. P.: Manual of Human Embryology, Philadelphia, J. B. Lippincott Company, 1912, vol. 2, p. 295.

4. Peyron, A.: Les vestiges embryonnaires de la région sacrococcygienne et leur rôle dans la production des kystes ou tumeurs d'origine congénitale, Bull. Assoc. franç. p. l'étude du cancer **17**:613, 1928.

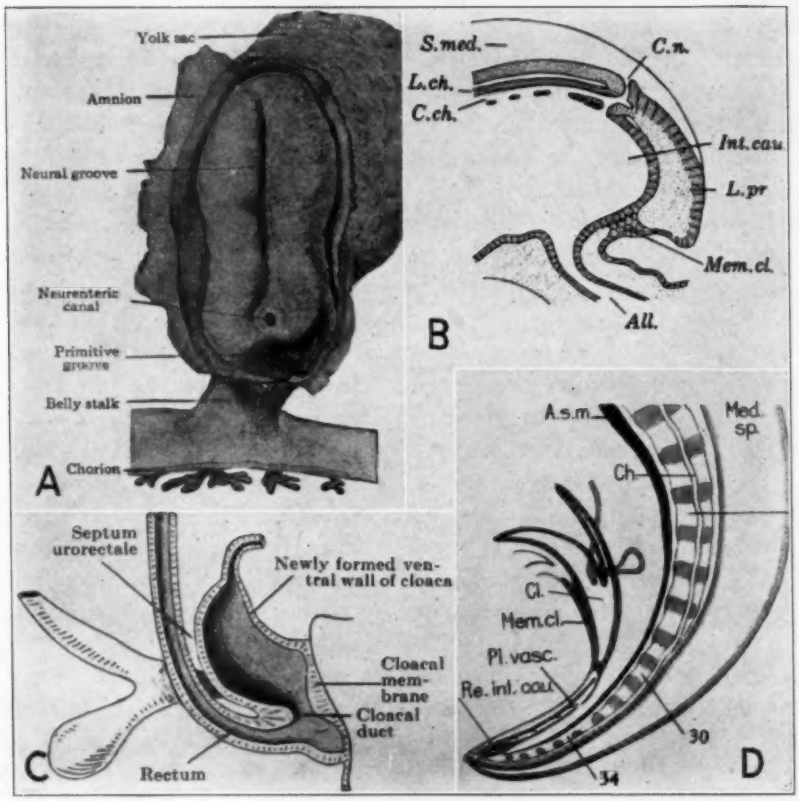

Fig. 1.—*A*, dorsal view of a human embryo 2 mm. in length, with yolk sac. The amnion is opened dorsally (after von Spee and Kollmann, from Keibal and Mall.[3])

B, Eternod's embryo of 2.1 mm. *All.* allantois; *C. ch.*, chordal canal; *C. n.*, neurenteric canal; *L. ch.*, chordal plate; *L. pr.*, primitive streak; *Mem. cl.*, membrana cloacalis; *S. med.*, medullary groove; *Int. cau.*, intestinum caudale. (From Keibal and Mall.[3])

D, embryo of 6.6 mm. The tail has attained nearly its maximum development and will gradually take on a more atrophic appearance. The lines along the dorsal margin of the spinal cord represent the boundaries of the myotomes. Note the beginning separation of the cloaca into dorsal and ventral portions. Note also the isolated caudal gut vestige. *A. s. m.*, arteria sacralis media; *Ch.*, chorda dorsalis; *Med. sp.*, medulla spinalis; *Cl.*, cloaca; *Mem. cl.*, membrana cloacalis; *Pl. vasc.*, plexus vasculosus; *Re. int. cau.*, remnant of caudal gut. (From Kunitomo.[1])

C, embryo of 7 mm. The cloaca is divided into rectum and ventral remains of the cloaca by the urorectal septum. The cloacal duct remains as a communication between the two for a time. (From Keibal and Mall.[3])

obliterated, forming a cell strand known as the atrophic cord (fig. 2). At about this time (third month) the relative overgrowth of the vertebral column over the spinal cord occurs, giving the appearance of ascension of the cord in the spinal canal. Remnants of the atrophic cord become dilated and segregated, forming the coccygeal medullary vestige. According to Kunitomo [1] this vestige is usually present and attains its greatest development at the fifth month, forming a white mass about 2 mm. in length in the subcutaneous tissue dorsal to the last coccygeal vertebra. It is composed of tubules which are lined with both stratified squamous and cylindric epithelium, and at birth it has atrophied to a great extent.

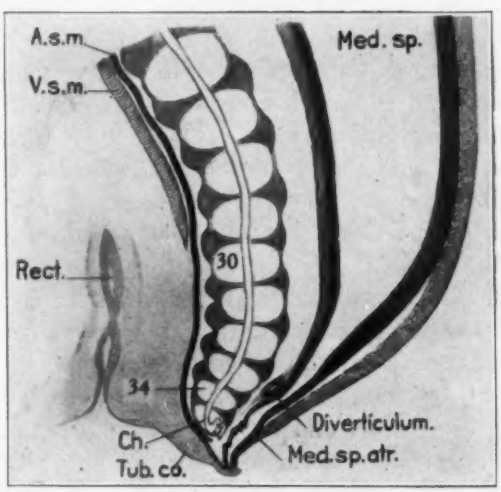

Fig. 2.—Embryo of 25 mm. Note the apparent diverticulum of the atrophic cord. The narrowing of the lumen of this portion of the cord appears to be a characteristic preliminary to its transition into the filum terminale. The two dilatations of the terminal intestine are the "bulbus analis" and the "bulbus terminalis." *V. s. m.*, vena sacralis media; *Rect.*, rectum; *Med. sp. atr.*, atrophic portion of spinal cord; *Tub. co.*, coccygeal tubercle. Remainder of abbreviations as noted in figure 1 *C*. (From Kunitomo.[1])

These vestiges have been thought by some to give rise to pilonidal cysts and sinuses. Recently, Stone [5] and Fox [6] have investigated such congenital lesions and have concluded that they develop from centers of growth in the basal layer of the ectoderm, which gives rise to hair follicles and glands. These authors found that such a process of ectodermal invagination is a normal occurrence, and that usually the struc-

5. Stone, H. B.: Pilonidal Sinus, Ann. Surg. **79**:410, 1924.

6. Fox, S. L.: The Origin of the Pilonidal Sinus, Surg., Gynec. & Obst. **60**:137, 1935.

tures formed disappear. They suggested that it is the same anlage which gives rise to the "preen gland" in certain birds and to analogous structures in certain mammals and reptiles. All of these seem to have a sexual function.

The notochord, which forms the primitive axial skeleton, arises just dorsal to the digestive tube (fig. 1 *B*). Whether it originates from entoderm or from mesoderm has been long debated. Caudal to the termination of the notochord the primitive streak extends to the cloacal membrane, thus passing around from the dorsal to the ventral side.

The evolution of the caudal portion of the notochord is not as well understood as is that of its cranial end. In the period during which the embryo is from 7.5 to 11 mm. in length the greater part of the notochord is embedded in the primitive vertebral column and shows considerable winding.[1] Intervertebral swellings begin to form; fragmentation progresses, and the cartilage of the vertebrae incorporate the vestiges more and more while transforming them. According to Peyron,[4] the last coccygeal vertebra is formed as a result of fusion of several vertebrae, and this would seem to account for the relative excess of notochordal tissue found in this region.

Vestiges also remain in the region of the spheno-occipital synchondrosis and in the nucleus pulposus of the intervertebral disks. The tissue has a jelly-like appearance and may resemble hyaline cartilage.

The entoderm of the primitive intestinal canal is closed to the exterior for a time but comes into direct relation with the surface ectoderm at the pharyngeal and cloacal membranes. Both of these structures lose their primitive position and become folded into the substance of the embryo through increase in the surrounding mesoderm. The cloacal membrane (figs. 1 *B* and 1 *D*) is formed from the ventral portion of the primitive streak at the time of its displacement in the formation of the tail fold through the disappearance of the intervening mesoderm. The cloacal membrane indicates the division between the terminal portion of the intestine and the tail gut, which normally disappears (fig. 1 *D*). With the development of the wolffian ducts the true cloaca is formed. It represents the common terminal cavity of both the urogenital and the intestinal tract. Subsequently, the separation of the cloaca into a ventral urogenital portion and a dorsal intestinal portion is effected by downgrowth of a coronal urorectal septum (fig. 1 *C*), which is complete at the stage in which the embryo is about 16 mm. in length.[7] The urorectal septum also divides the cloacal membrane into an anterior urogenital membrane and a posterior anal membrane.

Meanwhile, shrinkage in size does not affect the tail gut evenly throughout its length but is less marked at the caudal extremity, where

7. Johnson, F. P.: Development of the Rectum of the Human Embryo, Am. J. Anat. **16**:1, 1914.

a cord of cells is found even after all traces of primitive connection with the cloaca have disappeared (fig. 1 *D*). The tail gut is said to appear with the tail and to accompany the tail in its development and resorption.[8] It appears at about the 3.5 mm. stage, and normally it has completely disappeared in an 8 mm. embryo. Peyron [4] in an exhaustive study of this structure observed it 10 times in caudates and has presented important data on its histologic and topographic characteristics. He has noted that the early digestive tube is lined with stratified cuboidal epithelium two to four layers thick. The tail gut vestige and the intestinal tube from which it develops are histologicaly similar. Normally the tail gut vestige fills with epithelial débris and mucus and then rapidly disappears.

At the stage in which the embryo is 13.6 mm. in length the rectum presents a relatively large spindle-shaped swelling, which Johnson [7] has termed the "bulbus analis" (fig. 2). At the lower end of this swelling the epithelial tube becomes much decreased in size, but just before the cloaca is reached it gradually increases again. The short, lower widened portion has been called the "bulbus terminalis" by the same author. After division of the cloaca and the cloacal membrane into dorsal and ventral portions by the urorectal septum, invagination of the ectoderm of the anal membrane occurs, together with absorption of the intervening mesoderm. A pit is thereby formed, which is termed the proctodeum. Here the ectoderm and entoderm come into contact, and at about the 32 mm. stage perforation of this partition occurs and continuity of the terminal intestinal tract with the ectoderm is established. The junction of the anal and the rectal segment is marked in the adult by the "pectinate," or "white line of Hilton." The bulbus analis forms the lower portion of the ampulla recti in the adult, while the bulbus terminalis forms the zona intermedia of the anorectal canal. In the process of division a portion of the primitive cloaca is included in the bulbus terminalis in the formation of the zona intermedia of the adult. Thus this segment of the anorectal canal, which measures 5 to 12 mm. in length, is derived from the same anlage as the terminal urogenital tract. The crypts and columns of Morgagni develop in this area, and from the crypts tubular glandlike structures extend into the submucous and muscular layers of the rectum. These are called anal ducts or anal glands (fig. 3) and usually number less than six or eight. Gordon-Watson and Dodd [9] pointed out that the glands grow outward into the

8. Pohlman, A. G.: Development of the Cloaca in the Human Embryo, Am. J. Anat. **12**:1, 1911.

9. Gordon-Watson, C., and Dodd, H.: Observations on Fistula in Ano in Relation to Perianal Intramuscular Glands, Brit. J. Surg. **22**:703, 1934.

loose tissue within the internal sphincter and into the limiting annulus of connective tissue which separates the internal sphincter above and the external sphincter below. They may spread to (1) the superficial surface of the levator ani muscle and into the ischiorectal fossa; (2)

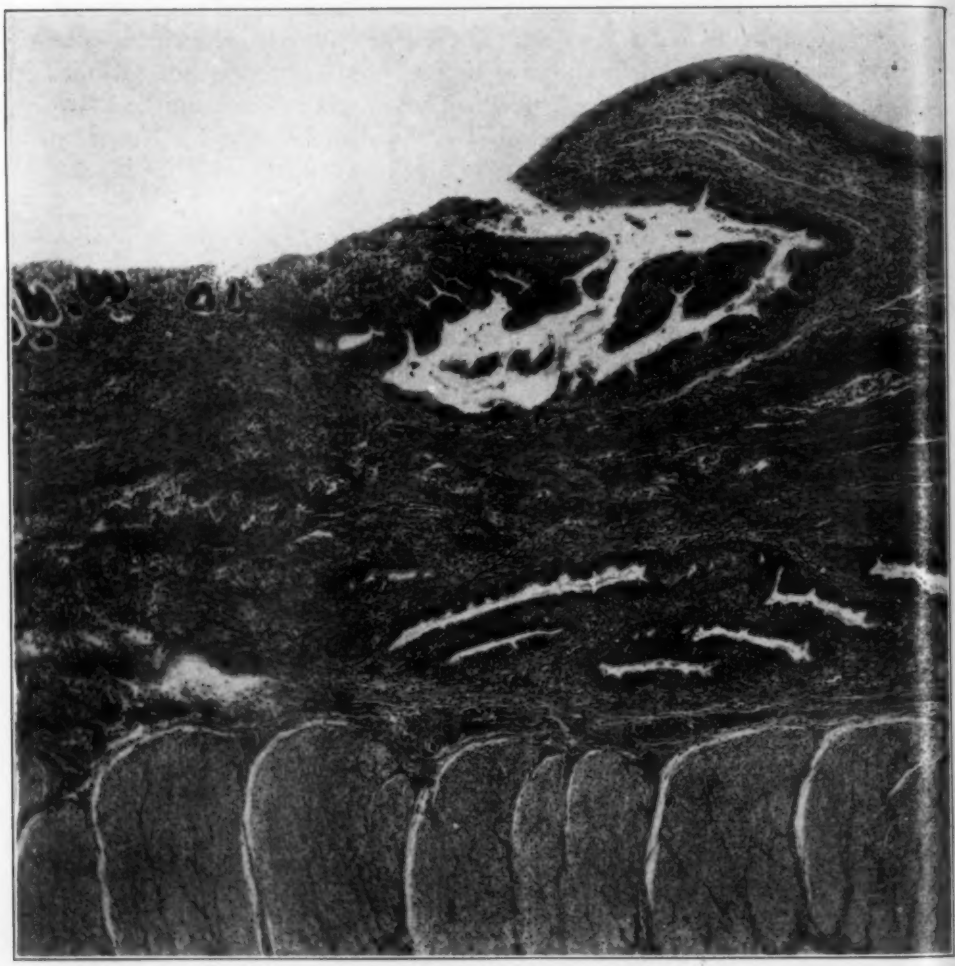

Fig. 3.—Section through the anorectal canal of an infant aged 1 month. Note the large crypt and beneath this the anal glands deep in the submucosa.

deep to the levator ani muscle and into the true pelvis, or (3) into the substance of the levator ani muscle. They are lined by several layers of polygonal cells in the main ducts and one to two layers of cuboidal cells in the branches. Mucin-secreting cells are usually present.

Misplacement of ectoderm [10] during the formation of the caudal extremity, especially with improper closure of the dermal cleft or resorption of the cloacal membrane, may give rise to cysts of the perineum or the pelvic connective tissue or to raphes of the scrotum and penis.

It has been concluded by Vallois and Peyron [11] that a plexus of blood vessels derived from the embryonic vascular channels, similar to the caudal artery and its corresponding vein in lower animals, gives rise to the coccygeal glomus. It was formerly thought to consist of a single body measuring about 2.5 mm., lying in front of the apex of the coccyx. It is now known, however, that there may be several irregular sinusoid masses, which are very vascular. Masson [12] has described the neural and smooth muscle elements wrapped about an arteriovenous anastomosis similar to a subungual glomus.

DESCRIPTION OF CASES AND COMMENT

No tumors or cysts of the coccygeal medullary vestige or of notochordal vestiges are included in the present study.

Tail Gut Vestiges.—We prefer the term "tail gut" or "caudal gut" to "postanal gut" because it gives a more precise description of the origin and location of this structure. Peyron [4] observed that the tail gut vestige in the caudate embryo consisted of a more or less elongated vesicle formed of intestinal epithelium containing mucous glands, lying below the anus and in front of the neurovascular structures (fig. 1 *D*). No distinct muscular or serous coats were present. He noted that considerable variation in the types of epithelium in any one specimen was possible and that this variation corresponded to the degree of metaplasia found in cysts arising from this vestige.

Peyron [4] suggested that an anterior sacrococcygeal or retrorectal cyst containing an epithelial lining of the intestinal type (including cells which take the mucicarmine stain) and having no definite muscular or serous coat could be assumed to be of tail gut origin.

Middeldorpf [13] in 1885 described a mucus-containing cystic postanal tumor the size of an egg, which was removed from a girl 1 year old. Histologically it was composed of areolar tissue and a fragment of intestine similar to normal intestine. Tubules, resembling Lieberkühn's

10. Ewing, J.: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928, p. 1036.

11. Vallois, H., and Peyron, A.: Sur les premiers stades du développement due glomérule coccygien chez l'homme, Compt. rend. Acad. d. sc. **170**:894, 1920.

12. Masson, P.: Le glomus neuromyo-arterial des régions tactiles et ses tumeurs, Lyon chir. **21**:257, 1924.

13. Middeldorpf, K.: Zur Kenntnis der angebornen Sacralgeschwülste, Virchows Arch. f. path. Anat. **101**:37, 1885.

glands, and muscle layers were described. No serous coat was found. This case has been generally accepted as the first instance of a tumor of caudal gut origin to be reported in the literature.

Galletly [14] in 1924 reported a carefully studied case which fulfils Peyron's criteria. A woman aged 43 presented a cyst between the coccyx and the gluteal region, which had been subjected unsuccessfully to local excision on several occasions. Laparotomy allowed complete removal. The wall of the cyst showed squamous epithelium with intracystic tufts composed of columnar cells of the intestinal type. Some granulation-like tissue and numerous foreign body giant cells were described.

Subsequently, several cases have been described. Among these are some which present features that make their inclusion in this group questionable and others that were incompletely described, making satisfactory interpretation impossible.

Thomason [15] described 2 cases. From the description, the tumor in the first seems to have been of caudal gut origin. However, the author added: "The history of its having been removed at a previous operation suggests, of course, that our tumor whatever else it may be is a teratoma, perhaps a 'suppressed twin.'" The second case is almost devoid of any descriptive data. In it the condition was associated with several anomalies, such as an enlarged tail-like coccyx and nonfusion of the lamina of the first sacral vertebra.

In Robertson and Wride's [16] case, the cyst contained bone and ganglion-like cells in addition to what was believed to be intestinal epithelium.

Ravin [17] reported 1 case in which the condition occurred in an infant 2½ months old. His only comment was: "The cyst is lined with several layers of cells the innermost of which is columnar and ciliated."

Ballantyne [18] has reported a carefully studied case which he regarded as an instance of carcinoma arising in a postanal gut vestige in a woman aged 38. Histologically the cyst showed an intestinal glandlike arrangement of lining composed of columnar epithelium. Goblet cells were present, and at one point frankly carcinomatous tissue was found.

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14. Galletly, A.: Presacral Tumors of Congenital Origin, Proc. Roy. Soc. Med. (Sect. Obst. & Gynec.) **17**:105, 1924.

15. Thomason, T. H.: Cysts and Sinuses of the Sacrococcygeal Region, Ann. Surg. **99**:585, 1934.

16. Robertson, F. N., and Wride, G. E.: Case of Persistent Cyst of Postanal Gut Origin in an Adult, Canad. M. A. J. **31**:535, 1934.

17. Ravin, R. W.: Sacrococcygeal Cysts and Tumors, Brit. J. Surg. **23**:337, 1935.

18. Ballantyne, E. N.: Sacrococcygeal Tumors: Adenocarcinoma of Cystic Congenital Embryonic Remnant, Arch. Path. **14**:1 (July) 1932.

Records of 2 cases in which we believe the condition to have been of caudal gut origin are found in our files.

CASE 1.—A woman aged 26 complained of pain on defecation for three months and of pains vaguely located in the lower part of the abdomen for seven years. There had been rather severe constipation but no tenesmus. No pus, blood or mucus had been observed in the stool. The patient had undergone an appendectomy seven years before and a cyst had been removed from the left ovary two years before at another hospital.

Examination revealed a soft swelling to the left of the urethral orifice and an anal fistula 3 cm. in length opening into the posterior commissure at the mucocutaneous junction. The tract seemed to pass around to the left anterior rectal wall. No masses were noted. Incision and drainage of what was thought to be a submucous abscess were performed. The external sphincter was divided at the posterior commissure, and the sinus was packed with iodoform gauze.

The patient continued to have occasional rectal pain and constipation, but the wound healed satisfactorily. Seventeen months later, however, there was recurrence of acute anorectal pain, together with passage of a considerable quantity of pus and blood.

Examination showed an elevated bluish red area about 4 cm. from the anus on the posterior anorectal wall. Greenish yellow pus was seen exuding from an opening in this area. This was thought to represent a recurrent submucous abscess, and incision and drainage, together with curettage, were carried out. Unfortunately no pathologic studies were done at this time. Healing was unsatisfactory, and the patient was referred to Dr. Charles L. Janssen, who made the following note: "Just at the mucocutaneous junction a sharp-edged opening is felt. Above this an ovoid mass about 5 by 3 cm. is encountered. It is soft, not fluctuant and exquisitely tender. The size of the mass suggests the possibility of a cyst being associated with the abscess."

A third operation was performed one month later, at which time it was recognized that a rather large multilocular cyst or multiple cysts, some containing clear mucus and others caseous material, lay in the posterior rectal region. Complete excision was not attempted, but several portions were removed and the wound was packed with gauze. The postoperative course was complicated by a hemorrhage on the ninth day, together with cystitis and some psychotic manifestations. A more radical surgical procedure was planned, but subsequently the patient went to another hospital and was lost to the follow-up clinic.

Sections (fig. 4) of the specimen showed a multilocular cyst filled with material which took the mucicarmine stain. The epithelial lining elements showed metaplasia. Stratified squamous and stratified columnar cells were most numerous, and in some portions definite Lieberkühn crypts appeared. Frequent acini of clear columnar cells and many mucin-secreting cells were found. The arrangement definitely suggested intestinal mucous membrane. No cilia, intercellular bridges, keratohyaline granules or argentaffin cells were observed. Occasional scattered groups of smooth muscle bundles were present in the periphery, but no definite muscular or serous coats were found.

CASE 2 (Submitted by Dr. George H. Semken).—The patient was a woman aged 36. The tumor was found during the course of a gynecologic examination. It had given the patient no symptoms.

Digital examination revealed an ellipsoid mass at the left side of the rectum, just in front of the coccyx. It seemed well defined and encapsulated and was soft rather than fluctuant.

At operation it was found that the mass, which measured 2.2 by 1.8 cm., lay external to the fascia propria of the rectum and was partly incorporated in the coccygeal portion of the levator ani muscle. The tumor was easily removed, and convalescence was uneventful.

The specimen contained about 4 cc. of thick brownish material composed of degenerated epithelium and amorphous débris. Fibroareolar tissue covered the

Fig. 4 (case 1).—Section through a portion of a caudal gut cyst. Note the several types of epithelium present.

external surface of the cyst. The wall averaged 1 to 2 mm. in thickness, and the inner surface presented a smooth, almost velvety, appearance.

Sections (fig. 5) through the wall of the cyst showed it to be lined in part by three types of stratified epithelium: squamous, columnar and ciliated. The last two are mucin-secreting membranes. A definite tendency to glandular formation was seen in some areas. Elsewhere a granulation-like tissue containing large num-

bers of pigment-laden phagocytes formed the lining of the cyst. In the wall a few scattered smooth muscle fibers were seen. No keratinization, formation of intercellular bridges or other evidence that might suggest an ectodermal origin of this cyst was found.

CLOACAL VESTIGES

Anal Glands.—A large number of anal glands have been observed in conjunction with regional disease as well as incidental to the examina-

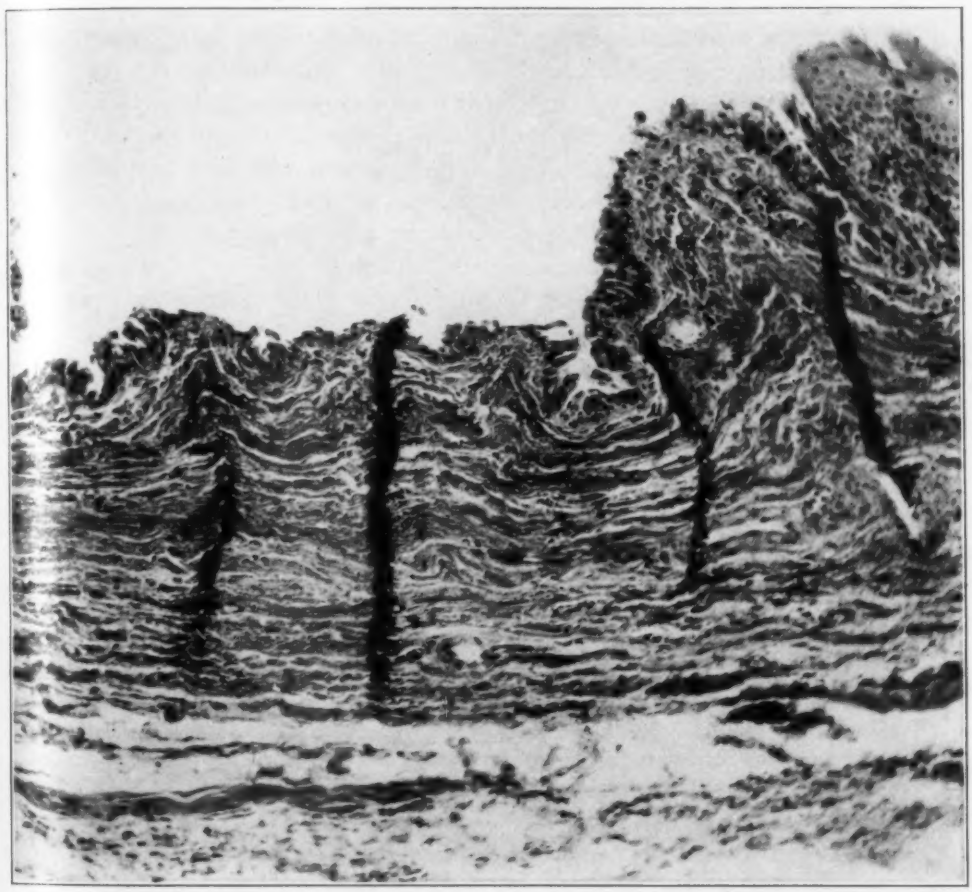

Fig. 5 (case 2).—Section through the wall of a caudal gut cyst.

tion of anorectal specimens. They seem to be vestiges of the primitive cloaca. The frequency with which they have been designated "supernumerary rectal glands," "postanal gut fistulas," "heterotopic rectal mucosa" and "epithelized fistulous tracts" in our series has prompted us to review these specimens in conjunction with the present study.

Herrmann and Defosses [19] first suggested that fistula in ano might be caused by anal glands. Several brief studies appeared subsequently, and in 1929 Lockhart-Mummery [20] referred to them as a possible cause of fistula and pointed out that these structures had apparently been overlooked by anatomists and surgeons. Relatively few references to these obviously important structures appeared until, in 1930, Tucker and Hellwig [21a, b] pointed out the fact that the crypts of Morgagni are not in themselves responsible for the frequency of anal infections. As a rule, these infections are due to the "anal ducts" which open into the crypts and provide a ready path for infecting organisms to enter the wall of the anal canal, resulting in cryptitis, periproctitis, fissures and fistulas. They noted that the anal ducts appear in the embryo at the same time as the prostate and periurethral glands and have a distinct histologic resemblance to these organs. In addition, they pointed out that the biologic characteristic of harboring the rather easily destroyed gonococcus is common to these related structures.

Two cases in which rather prominent anal glands were found are reported.

CASE 3.—A white man aged 36 complained of anal pain, pruritus and hemorrhoids of about four years' duration.

Examination revealed a chronic fissure in ano with a sentinel pile in the posterior commissure. About 1 cm. superior to the fissure a fistulous opening about 2.5 cm. in length was demonstrated. Internal hemorrhoids were also present.

At operation the tract was injected with methylene blue, and excision of the fissure and the fistula as well as of the hemorrhoids was performed.

The wound seemed to heal slowly, and several months later it was noted that a second fissure had appeared at the same site. Reoperation was performed, and ultimate healing occurred.

Sections (fig. 6) of the fistula revealed a large, tortuous compound glandular structure lined by stratified columnar epithelium, which arose from a depression in the mucocutaneous junction. Mucin-secreting cells were frequent, and inflammatory cells were numerous throughout the supporting tissue. It is probable that the first operation was incomplete and that some of the epithelium remained, causing delayed healing and secondary fissure formation.

CASE 4.—A Chinese man aged 50 was admitted to the hospital with the clinical diagnosis of carcinoma of the stomach with metastases to the liver. There were no anorectal complaints. On routine examination a soft nontender mass measuring 2 cm. in diameter was found in the submucosa of the anterior rectal wall, just above the internal sphincter. Proctoscopic examination revealed a punched-out ulcer 5 mm. in diameter in the mucosa covering the mass. The mass and the ulcer

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19. Herrmann, G., and Defosses, L.: Sur la muqueuse de la région cloacale du rectum, Compt. rend. Acad. d. sc. **90**:1301, 1880.

20. Lockhart-Mummery, J. P.: Discussion on Fistula-in-Ano, Proc. Roy. Soc. Med. **22**:1331, 1929.

21. Tucker, C. C., and Hellwig, C. A.: (*a*) Anal Ducts, Arch. Surg. **31**:521 (Oct.) 1935; (*b*) Histopathology of Anal Crypts, Surg., Gynec. & Obst. **58**:145, 1934.

were excised, and the wound was closed. Convalescence was uneventful, but the patient succumbed to the intra-abdominal neoplasm about a year later.

Section of the specimen showed that the ulcer was situated slightly proximal to the mucocutaneous junction. Its base was covered with slough, and there was no granulation tissue or evidence of repair. At the mucocutaneous junction a large anal gland (fig. 7) wound about in a tortuous manner in the fibers of the

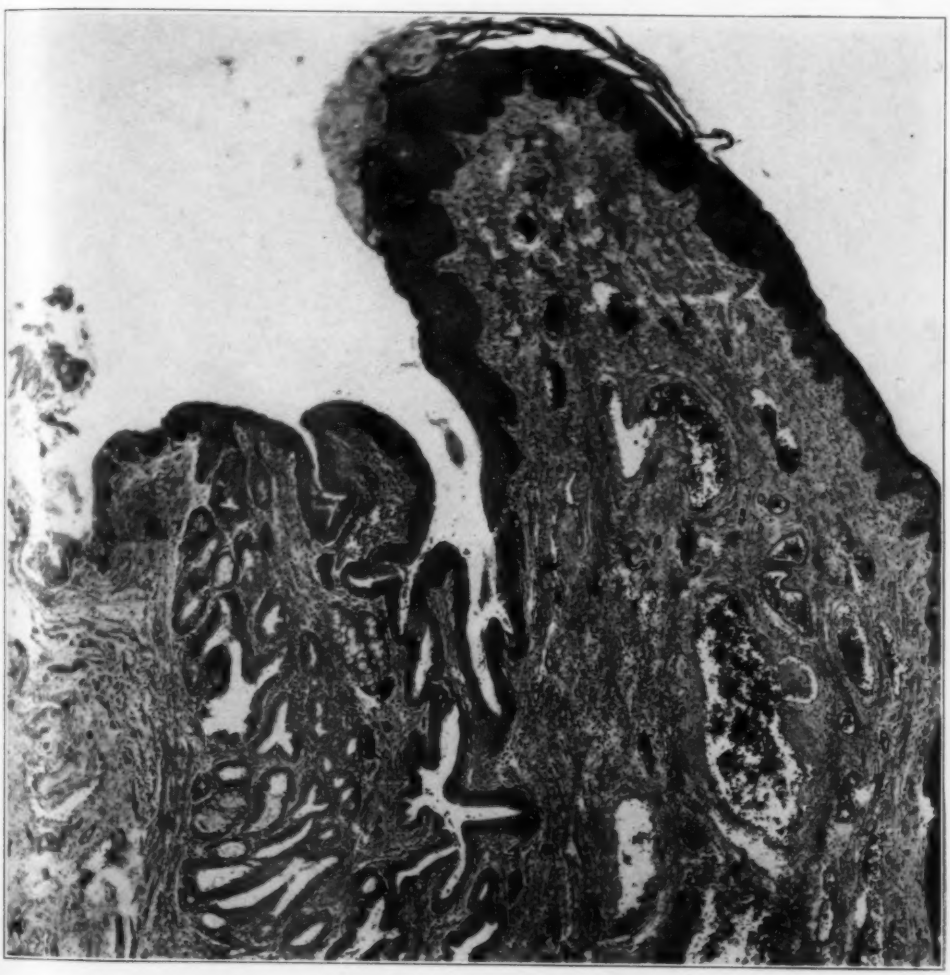

Fig. 6 (case 3).—Large anal glands associated with fistula and fissure in ano.

sphincter. It was lined with stratified columnar, mucus-producing epithelium, and in one or two places it blended with stratified squamous cells. There were no cilia. Several argentaffin cells were present in the mucosa of the anorectal canal but not in the glands. The sections did not indicate the cause of the ulcer; however, it is plausible to assume that the anal glands may have been associated with its production.

Vestiges of Cloacal Membrane.—The location of tail gut cysts is fairly well defined as retrorectal. Anterior rectal or perineal cysts may arise by persistence of remnants of the cloacal membrane or by heterotopia of the ectoderm of the dermal cleft. The presence of ciliated epithelium in cysts of vestigial origin is not particularly astonishing or

Fig. 7 (case 4).—Anal gland associated with rectal ulcer.

significant when it is recalled that ciliated epithelium is found lining many embryonal structures, such as neural, enteric, respiratory and genital canals (Ewing).

The cyst described in the following report we believe to have developed from the entoderm of the cloacal membrane.

CASE 5.—A white man aged 23 complained of a mass anterior to the anus, of many years' duration. There had been no noticeable changes in its size. During the week preceding his admission to the hospital the patient had observed a swelling in the sacrococcygeal region, associated with some pruritus.

Examination revealed a rounded pedunculated soft cystic mass about 2.5 cm. in diameter, attached to the anterior commissure of the anus. In addition, in the midline of the coccygeal region two very small openings were noted. There was some evidence of inflammation in this region. Digital and anoscopic examinations gave essentially negative results.

At operation the perineal mass was found to be adherent to the lower border of the external sphincter. It was easily removed. A sacrococcygeal cyst measuring 2.5 by 1.5 cm. was removed en masse. Recovery was uncomplicated.

The first specimen contained about 3 cc. of brownish yellow puslike material. The lining of the cyst was smooth and glistening. Microscopically (fig. 8) the lining showed a rather even stratified columnar ciliated epithlium with some evidence of the secretion of mucin. There was no definite suggestion of gland formation, and no epithelial metaplasia. In the fibrous tissue of the wall some smooth muscle was found.

The second specimen contained some amorphous material and a few hairs. Its lining was composed entirely of granulation tissue in which many foreign body giant cells were noted.

The perineal cyst would seem to be of cloacal rather than intestinal origin. The fact that no glands were present, as well as the anterior location of the cyst, would exclude the caudal gut vestige as a possible source of origin. Its association with a sacrococcygeal sinus is unusual but not remarkable. There is no evidence that the lesions were in any way related. The absence of epithelium in the sinus was probably due to the destructive influence of the inflammatory process which prompted the patient to seek medical treatment.

CASE 6.—A white woman aged 35 stated that she had first noticed a growth near the anus a year before. It had given slight pain and had bled on one occasion. Pruritus had been severe.

Examination revealed two tabs of skin attached to the posterior commissure of the anus. The larger of these tabs measured 1 cm. in diameter.

At operation a tract about 4 cm. in length was found arising from one tab and extending outside the external sphincter. The tract was sectioned, and several drops of pus escaped from it. Methylene blue was injected, but no internal opening could be discovered.

Convalescence was uneventful, and the sinus healed

Sections (fig. 9 and 10) through the larger tab showed that it contained two cysts, which differed histologically. One cyst was lined with stratified cuboidal and columnar epithelium. Many of the surface cells contained droplets of mucin. At intervals ciliated cells were found, isolated or in groups. Occasional cells in the basal layer contained granules which blackened with silver and had the appearance and characteristics of argentaffin cells. There was a tendency to squamous cell metaplasia in some areas, but no keratinization was found. Surrounding this cyst were great numbers of phagocytic cells the cytoplasm of which was distended by large numbers of coarse brown granules. From their staining reaction to scarlet red it is believed that they were lipoids.

In another portion of the cutaneous tab and apparently not communicating with the cyst just described was a second cyst (fig. 10). It was in part lined with stratified squamous epithelium, the flattened surface cells of which were hydropic and vacuolated and contained no keratohyaline granules. The basal layer of cells contained no melanin. In another portion of the cyst, stratified columnar cells were present. In a third part, no epithelium was found; instead, a loose, relatively

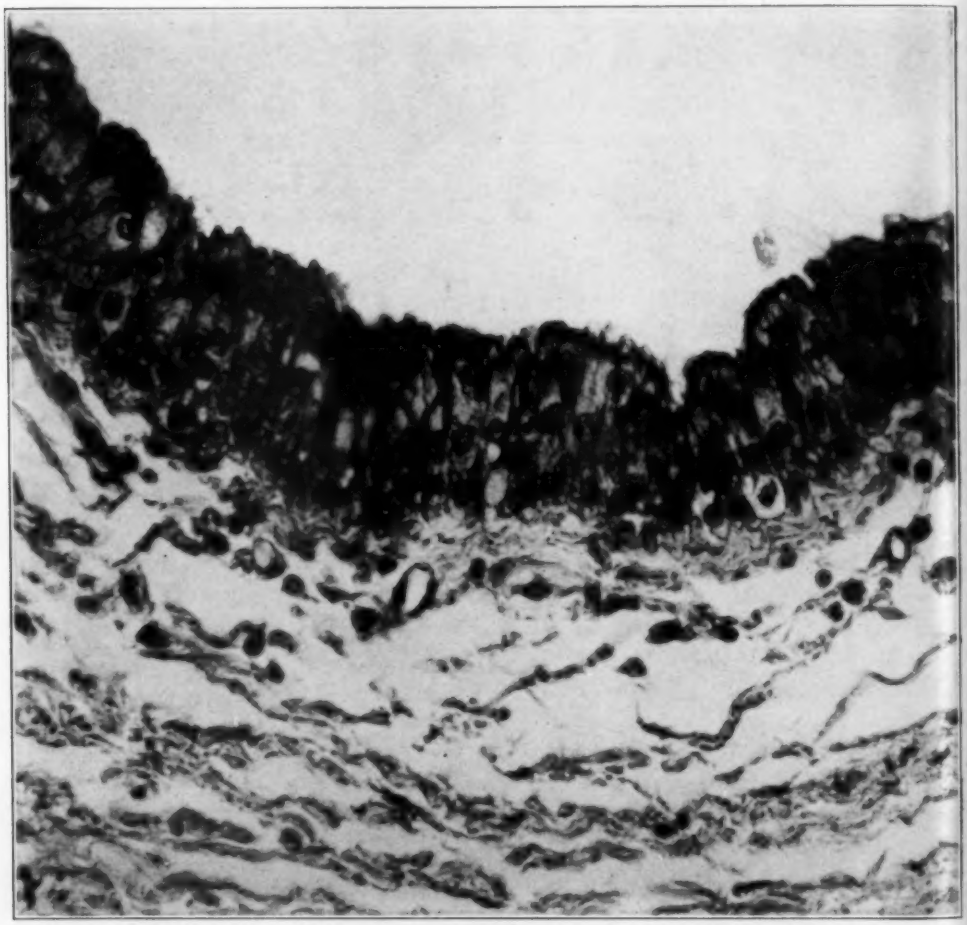

Fig. 8 (case 5).—Section through the wall of a cyst of the cloacal membrane. Note the cilia present.

avascular network of fibrous tissue containing large numbers of foam cells formed the wall of the cyst.

The definite histologic differences between these cysts would seem to indicate that they arose from different anlages. The presence of silver-positive cells which appeared to be argentaffin cells within one of the

cysts is the only observation which suggests intestinal origin. The distinct histologic resemblance of this cyst to that in the previous case leads us to believe that it was probably a vestige of the cloacal membrane. The second cyst almost certainly arose from heterotopia of the ectoderm of the dermal cleft.

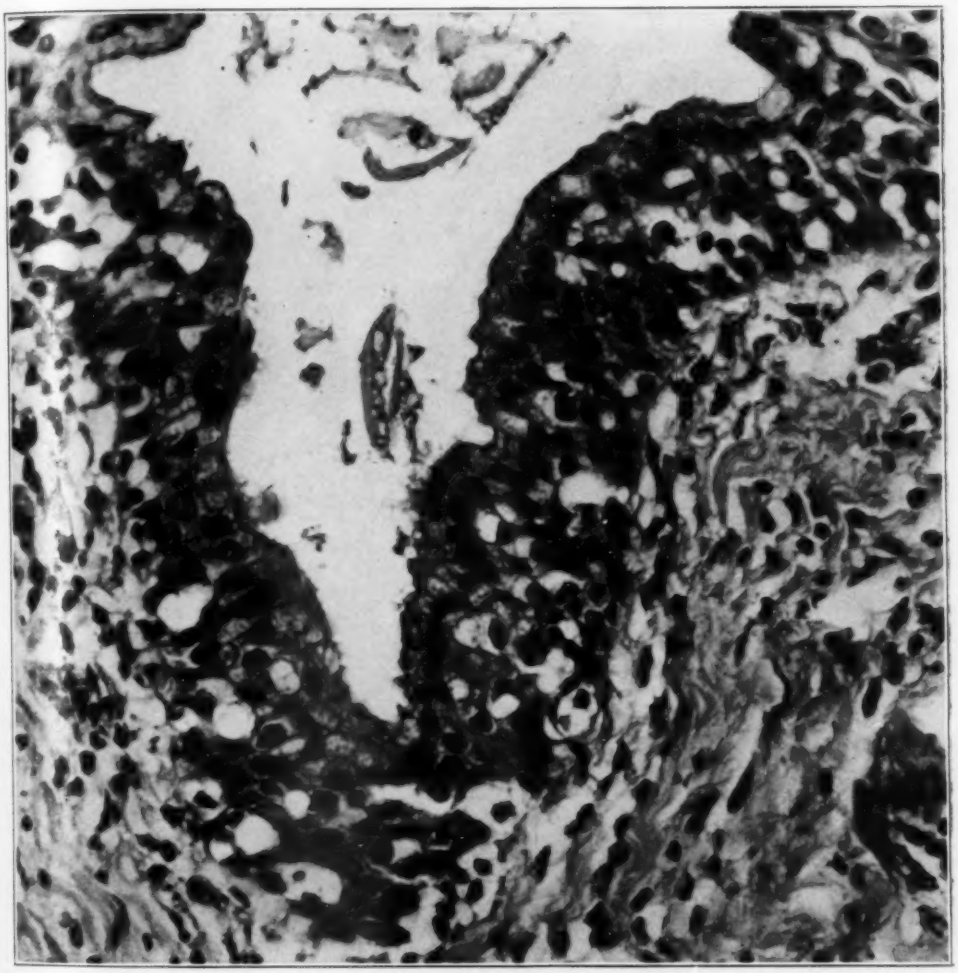

Fig. 9 (case 6).—High power photomicrograph of a section through a cyst of the cloacal membrane.

SUMMARY

The development of the caudal portion of the body is attended by numerous complex processes involving the medullary tube, the primitive intestinal tract, the notochord and the cloaca. Disturbances in development may lead to persistence of certain embryonal vestiges, which are

sometimes important factors in the production of cysts, tumors and fistulas of this region. From the number of cases reported in the literature one would judge that the persistence of vestiges is rare; however, they are probably more common than this would indicate. Vestiges of the cloaca are normally found in the anorectal canal, form-

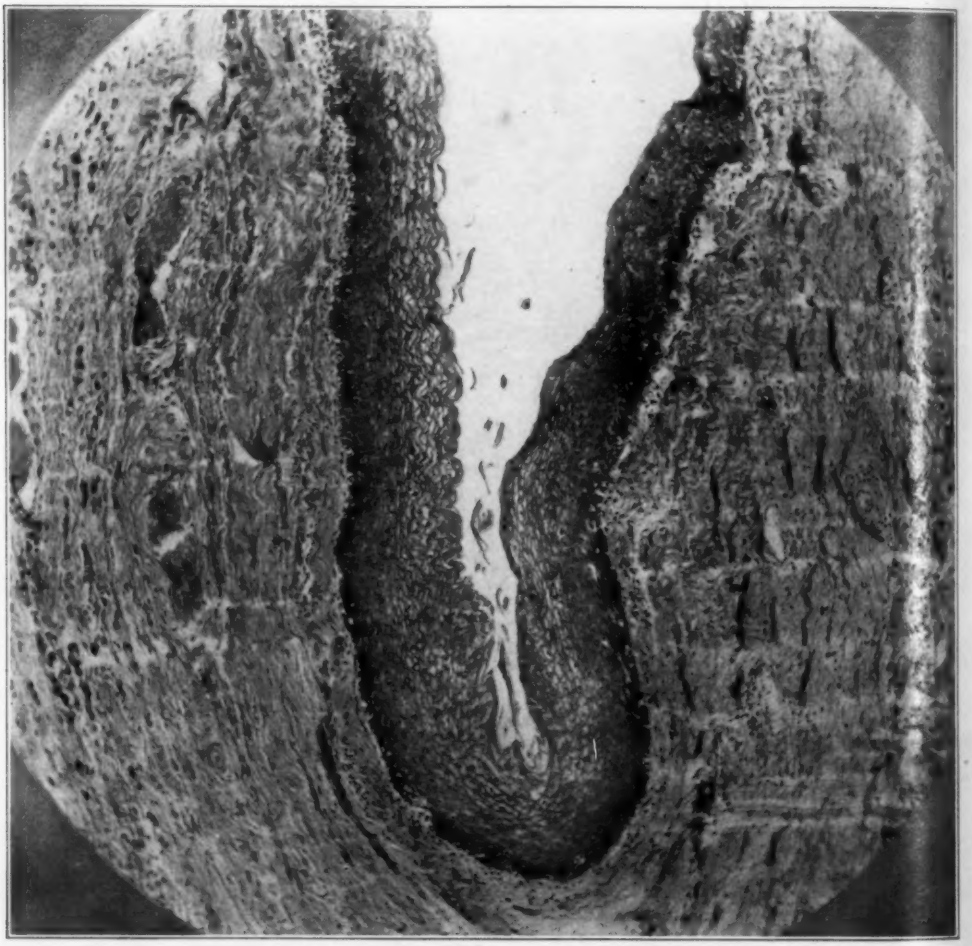

Fig. 10 (case 6).—Section through a cyst of ectodermal origin found adjacent to the cyst shown in figure 9.

ing the anal glands, which are extremely important in the causation of lesions of this area.

The histologic and topographic features of caudal gut cysts, as well as of cloacal cysts, are discussed. Two representative cases of each group are reported, and illustrative cases in which there were large anal glands are cited.

CONCLUSIONS

1. The presence of cysts of the perianal region can be explained on an embryologic basis, and the cysts may be classified according to their source.

2. Cysts of a single germ layer which are of embryonal origin may be derived from the caudal gut, the cloaca or the ectoderm of the dermal cleft.

3. Vestigial structures, such as the anal glands, are frequent sites of anorectal lesions, such as fistula, fissure and perirectal abscess.

MOTION OF THE LUNG AFTER SURGICALLY INDUCED PARALYSIS OF THE PHRENIC NERVE

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Differences of opinion are still encountered as to the mechanical effect of induced paralysis of the hemidiaphragm on the volume and function of the corresponding lung. Yates [1] expressed the opinion that the motion of the parietes of the chest can be limited by blocking the nerve trunks which transmit motor impulses to the diaphragm. He stated that surgical paralysis and consequent atony of the diaphragm induce a reduction in the movements of the thoracic parietes of the chest or, even if there are adhesions, a reduction in the volume of the lung, and the pulmonary excursions are limited to those immediately above and below the mean inflation. Lilienthal [2] said that clinical results and roentgenologic appearances led him to the conclusion that the elevation of the diaphragm after having crushed the phrenic nerve may effect a reduction in capacity the equivalent of from 200 to 500 cc. and also a decrease in the respiratory excursions. Bettman [3] recommended phrenicoexeresis for obtaining collapse and rest of the diseased lung. He estimated that the diminution of thoracic volume by the rise of the paralyzed diaphragm in an adult varies somewhere between 400 and 600 cc. Alexander [4] contended that mere relaxation of the lung and reduction of its volume necessarily cause a certain amount of pulmonary rest; elimination of the pumping function of the diaphragm, he said, is the most important single factor in resting the lung. He quoted Berard, who estimated that the volume of the lung is reduced from one fourth to one third by phrenicotomy, and Ziegler, whose estimate is one fourth.

Wilson [5] tabulated the data of other investigators concerning the influence of the diaphragm and the ribs on the normal respiratory

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From Muirdale Sanatorium.

1. Yates, J. L.: Operations as Aids in the Treatment of Pleuropulmonary Tuberculosis, Ann. Surg. **86**:200, 1927.

2. Lilienthal, H.: Mechanical Principles of the Operative Treatment of Pulmonary Tuberculosis, Ann. Surg. **86**:182, 1927.

3. Bettman, R. B.: Phrenectomy, Illinois M. J. **52**:374, 1927.

4. Alexander, J.: The Surgery of Pulmonary Tuberculosis, Philadelphia, Lea & Febiger, 1925.

5. Wilson, H., cited by Graham, E. A.; Singer, J. J., and Ballon, H. C.: Surgical Diseases of the Lung, Philadelphia, Lea & Febiger, 1935, p. 455.

volume. These data reveal that the diaphragm contributes from 37 to 47 per cent of the volume of respired air on quiet respiration. Eloesser and Brown [6] expressed the opinion that pulmonary rest is not very great after phrenicotomy. Straub [7] found that the loss of pulmonary volume which accompanies paralytic elevation of the dome of the diaphragm amounts to from 20 to 30 per cent. He stated that although a phrenic operation results in a certain amount of relaxation and immobilization of the corresponding lung, it carries with it the disadvantage of not absolutely eliminating the motion of the lung on account of the compensatory thoracic motion during respiration. It was shown by Schnippenkotter [8] and by Head [9] that the paralysis of the hemidiaphragm is compensated for chiefly by increased action of the homolateral ribs. Lambert [10] emphasized that the extent of the rise of the diaphragm should not be taken as the sole criterion on which to judge the efficacy of surgical operation on the phrenic nerve in any given case. The conception he expressed was that elimination of the phrenic pathway interrupts an important link in the mechanism coordinating the various factors of the respiratory function and thus leads the intercostal and abdominal muscles to act less vigorously. He stated the belief that this consequence, together with the loss of the contractile power of the diaphragm, results in a diminution of pulmonary expansion and contraction during respiration and effects a certain degree of rest in the pulmonary tissue.

Sisti and Soricelli [11] made kymographic studies of the chest before and after crushing of the phrenic nerve and were able to demonstrate that the excursions of the ribs increased after operation. The experimental studies of Strauss [12] led him to the conclusion that induced paralysis of the phrenic nerve does not immobilize the lung. A similar opinion was expressed recently by van Joost,[13] who said that the lack

6. Eloesser, L., and Brown, P. K.: Surgical Intervention in Pulmonary Tuberculosis: Pathological Conditions in the Lung and the Various Forms of Operations Applicable to Them, Am. Rev. Tuberc. **8**:519, 1924.

7. Straub, G. F.: Surgery of the Chest, Springfield, Ill., Charles C. Thomas, Publisher, 1932.

8. Schnippenkotter, W.: Surgical Paralysis of the Diaphragm, Beitr. z. Klin. d. Tuberk. **65**:56, 1926.

9. Head, J. R.: The Redistribution of Respiration Following Paralysis of the Hemidiaphragm, Surg., Gynec. & Obst. **50**:929, 1930.

10. Lambert, A. V. S.: Results of Operation Which Interrupts Nerve Impulses Along the Phrenic Nerve Pathway, J. Thoracic Surg. **4**:49, 1934.

11. Sisti, M. A., and Soricelli, F.: Roentgen-Kymographic Studies Following Phrenic Nerve Block, Arch. di radiol. **12**:108, 1936.

12. Strauss, L. H.: Effect of the Exeresis of the Phrenic Nerve, Beitr. z. Klin. d. Tuberk. **88**:374, 1937.

13. van Joost, C. R. N. F.: Notes on Phrenic Nerve Paralysis in the Treatment of Pulmonary Tuberculosis, abstracted, Zentralbl. f. d. ges. Tuberk.-Forsch. **46**:517, 1937.

of major immobilization of the lung following block of the phrenic nerve is due to the immediate compensatory ventilation induced by the increased motion of the ribs. Furthermore, Matson and Matson [14] stated that the beneficial effect of hemidiaphragmatic paralysis is due to the degree of collapse obtained in the diseased lung by the rise of the corresponding side of the diaphragm, rather than to any rest provided.

NEW METHOD OF STUDY

The object of the study reported in this paper was to ascertain the extent of motion of the treated lung by a new method for the determination of the respiratory expansion of the chest, devised by Hurtado and Fray.[15] They found that the degree of thoracic expansion can be estimated from the relation between the roentgenologic pulmonary fields at maximum expiration and inspiration. The roentgenograms used in my work were taken at the end of the two respiratory phases in the upright position on two films from a distance of 6 feet (180 cm.). The area of the fields was measured by means of a planimeter, the tracer of which was moved along the inner aspect of the ribs on the following course: from the left axilla, through the left half of the diaphragm, the right half of the diaphragm, the right lateral border of the lung and the right apex, and across the spine to the starting point at the left apex. A line was drawn corresponding to the position of the trachea and the mediastinal borders of the two lungs. Thus it was possible to measure the areas of the diseased and the "good" lung separately.

The figures on the differential wheel of the planimeter used indicate area in square centimeters. The roentgenologic respiratory ratio, R. R. R., was calculated according to the following formula: (roentgenologic area at maximum expiration/roentgenologic area at maximum inspiration) $\times$ 100. This ratio is inversely proportionate to the extent of the respiratory excursions: The higher the ratio, the smaller the motion, and vice versa.

Hurtado and Fray [15] stated that if the ratio thus calculated is higher than 72, a definite reduction in chest expansion may be suspected. My calculations showed that the ratio of the diseased lung before operation varied from 60 to 98. In 30 cases analyzed 2 values were between 60 and 69, 8 between 70 and 79, 14 between 80 and 89 and 6 90 or more. The roentgenograms were taken one month after operation in 25 cases, after a four-day interval in 2 (1 case of exeresis and 1 of

14. Matson, R. C., and Matson, R. W.: Phrenic Neurectomy, in Goldberg, B.: Clinical Tuberculosis, Philadelphia, F. A. Davis Company, 1935.

15. Hurtado, A., and Fray, W. W.: Studies of Total Pulmonary Capacity and Its Subdivisions, J. Clin. Investigation **12**:807, 1933.

phrenemphraxis), after a sixteen-day interval in 1 (phrenemphraxis), after a two and one-half month interval in 1 (phrenemphraxis), and after an eight-month interval in 1 (exeresis). Dr. F. Raine, visiting surgeon to the Muirdale sanatorium, performed all operations. I estimated the postoperative motion of the lung by comparing the ratios of both lungs after operation with the ratios of both lungs before operation. It must be remembered, however, that without due correction such a comparison may give a false impression. The force of the inspiratory and expiratory efforts may differ before and after operation. The true value of the motion of the diseased lung is determinable only if one corrects the areas according to the extent of motion on the "good" side.

An example may illustrate this point. Assume that before operation the expiratory area was 153 sq. cm. and the inspiratory area 191 sq. cm. on the "good" side; its R. R. R.: $\frac{153}{191} \times 100 = 80$. The diseased side had at the same time an expiratory area of 167 sq. cm. and an inspiratory area of 200 sq. cm.; its R. R. R.: $\frac{167}{200} \times 100 = 83$. The respiratory motion of the diseased lung is 3 (83 — 80) points less than that of the "good" lung. After operation, the expiratory area of the "good" lung is 142 sq. cm. and the inspiratory area is 184 sq. cm.; its postoperative R. R. R.: $\frac{142}{184} \times 100 = 77$. The motion increased by 3 (80 — 77) points when compared with the preoperative function. After operation, the diseased lung had an expiratory area of 153 sq. cm. and an inspiratory area of 168 sq. cm.; its postoperative R. R. R.: $\frac{153}{168} \times 100 = 91$. The motion decreased by 8 (91 — 83) points when compared with the preoperative function. The side not operated on shows a 3 point increase in motion while the side operated on has an 8 point decrease. In other words, as the result of operation, the side operated on has an 8 point decrease in motion instead of the 3 point increase of the side not operated on, that is, a *gain in rest* of 11 (8 + 3) points. The figure calculated according to this formula is designated as the relative index of motion of the lung operated on.

RESULTS OBTAINED BY NEW METHOD

My results show that the motion of the lung after induced paralysis of the corresponding phrenic nerve was reduced in 18 cases (60 per cent), remained unchanged in 5 (16.7 per cent) and increased in 7 (23.3 per cent). It is evident that 12 patients (40 per cent) did not derive from the operation the rest anticipated. All patients with an R. R. R. of 0 or 1 were considered as having the motion unchanged. The extent of the increased motion varied from 4 to 14 points. Of the 7 patients with increased motion, 2 had undergone exeresis and 5

temporary nerve block (phrenemphraxis). In the 18 instances in which postoperative motion of the lung was reduced, the degree of reduction was predominantly slight or moderate. It was less than 5 points in 5 cases (16.7 per cent of all the cases analyzed), between 5 and 9 points in 8 (26.6 per cent), between 10 and 14 in 4 (13.3 per cent) and between 15 and 19 in 1 (3.3 per cent). Only 4 of the 30 patients had undergone exeresis; of these increased motion was noted after operation in 2 (50 per cent). Of the 26 cases in which there was temporary paralysis, the pulmonary motion became decreased in 16 (61.5 per cent), remained unchanged in 5 (19.2 per cent) and increased in 5 (19.2 per cent). Of the 8 right-sided temporary blocks, the postoperative motion of the lung decreased in 4 (50 per cent), remained unchanged in 1 (12.5 per cent) and increased in 3 (37.5 per cent); of the 19 left-sided temporary blocks, the motion decreased in 12 (66.6 per cent), remained unchanged in 4 (22.2 per cent) and increased in 2 (11.1 per cent).

The actual rise of the diaphragm after operation on inspiration was 4 cm. or more in 4 cases, 3 to 3.9 cm. in 10, 2 to 2.9 cm. in 4, 1 to 1.9 cm. in 7, less than 1 cm. in 2 and absent in 3. On expiration the actual rise was 4 cm. or more in 2 cases, 3 to 3.9 cm. in 1, 2 to 2.9 cm. in 7, 1 to 1.9 cm. in 11, less than 1 cm. in 8 and absent in 1. Excursions of 0.2 cm. were classified as "motion absent." The relative rise of the diaphragm (corrected according to the motion of the diaphragm on the "good" side) was 4 cm. or more on inspiration in 7 cases, 3 to 3.9 cm. in 6, 2 to 2.9 cm. in 9, 1 to 1.9 cm. in 4, less than 1 cm. in 1 and absent in 3. The relative rise on expiration was 4 cm. or more in 1 case, 3 to 3.9 cm. in 5, 2 to 2.9 cm. in 6, 1 to 1.9 cm. in 8, less than 1 cm. in 7 and absent in 3.

The actual postoperative motion of the corresponding dome of the diaphragm decreased in 21 cases (70 per cent), remained unchanged in 4 (12.6 per cent) and increased in 5 (16.7 per cent). The increase amounted to from 27 to 266 per cent of the extent of the preoperative motion. The increased diaphragmatic motion is explainable by one or more of the following factors: (1) tug of the opposite diaphragm, (2) release of adhesions and (3) artificial pneumothorax on the side operated on. Two of the patients had simultaneous contralateral artificial pneumothorax, another bilateral artificial pneumothorax and two others homolateral artificial pneumothorax.

A comparison was made between the preoperative motion of the diaphragm and the postoperative motion of the affected lung. We found that, with the exception of 1 case in the group with motion of 2 to 2.9 cm. and 1 case in the group, with motion of 3 to 5 cm., all cases with increased or unchanged pulmonary motion were ones in which the preoperative diaphragmatic motion was less than 2 cm. In

3 instances actual diaphragmatic motion was absent postoperatively; still the relative motion of the lung was reduced by from 3 to 9 points.

In the group in which the postoperative diaphragmatic motion was less than 1 cm., the reduction of the pulmonary motion varied from 0 to 12 points, and it was increased in 2 instances 6 and 14 points respectively. In the group with postoperative diaphragmatic motion of 1 to 1.9 cm., the pulmonary motion was reduced by from 1 to 14 points. In the group with diaphragmatic excursions of 3 to 5 cm., the reduction of the motion of the lung varied between 0 and 19; a 4 point increase occurred in 1 instance and a 7 point increase in another.

Considering the relation between the R. R. R. of the treated lung before and after operation, we found, except in 1 instance, no postoperative increased motion in cases in which the preoperative R. R. R. was less than 80. The reduction of motion in the group with an R. R. R. of 60 to 69 varied from 3 to 8, and in the group with an R. R. R. of 70 to 79 from 1 to 19; increased motion was noted in 1 case. Of the 14 cases with a preoperative R. R. R. of 80 to 89 the postoperative pulmonary motion increased in 5; in the group of 6 cases with a preoperative R. R. R. of 90 or more motion increased in only 1.

The relation between the type pulmonary or pleural disease and the postoperative motion of the lung was also studied. Of the 2 patients who were operated on because of tuberculous plastic pleurisy, 1 showed decreased pulmonary motion after operation and the other showed increased motion. Of the 6 cases of minimal pulmonary involvement, the motion decreased in 4, increased in 1 and was unchanged in 1. Of the 16 cases of moderately advanced involvement, in 10 the motion decreased, in 3 it increased and in 3 it remained unchanged. Of the 6 cases of far advanced involvement, decreased motion was observed in 3, increased motion in 2 and unchanged motion in 1. The influence of basal pleural adhesions that were demonstrable on the roentgenogram is reflected by the following data: Of the 11 cases belonging to this group, increased postoperative motion was noted in 4 (36.3 per cent) and unchanged motion in 2 (18.1 per cent). The degree of increased motion ranged from 5 to 14 points. Reduced motion was present in 5 cases (45.4 per cent).

SUMMARY AND CONCLUSION

A roentgenologic study of the change in the motion of the lung after surgical operation on the phrenic nerve is presented.

The analysis was made according to the new method of Hurtado and Fray, by determining the roentgenologic respiratory ratio (R. R. R.), that is, by calculating the relation between the roentgenologic area of the lung on maximum expiration and that on maximum inspiration.

The relative (or comparative) roentgenologic index of motion is shown to be a closer reflection of the true dynamics of a lung that has been operated on than those figures which express the actual difference in extent of motion without regard to increase or decrease in respiratory excursions of the lung not subjected to operation.

Although it is realized that the data presented in this work bear the limitations of a study based on a small number of cases, they throw some light on the question of pulmonary rest after operation on the phrenic nerve. I found that the motion of the lung after induced paralysis of the corresponding phrenic nerve decreased in 18 cases (60 per cent), remained unchanged in 5 (16.7 per cent) and increased in 7 (23.3 per cent). In other words, the anticipated postoperative pulmonary rest was not accomplished in 40 per cent of the cases.

EXPERIMENTAL PYLORIC AND JEJUNAL OBSTRUCTIONS

ABSORPTION OF SODIUM CHLORIDE FROM THE STOMACH AND THE UPPER PART OF THE SMALL INTESTINE

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Previous experimental work [1] has suggested that absorption of water from the stomach and the upper part of the small intestine in the presence of organic obstruction may be of some therapeutic importance. Dogs with obstruction of the upper part of the jejunum, 15 cm. below the ligament of Treitz, lived more than twice as long as animals receiving nothing by mouth and lost less weight when permitted to drink water. This indicates that water was absorbed from the upper part of the intestinal tract, in spite of obstruction and continued vomiting.

A series of experiments has been done to determine the effect on the length of life of animals with jejunal obstructions of drinking a solution of sodium chloride, a solution of 10 per cent alcohol and a combination of alcohol and solution of sodium chloride. In a second series the pylorus was obstructed and a comparison made of the chemical changes in the blood of animals receiving solution of sodium chloride and water.

TECHNIC OF EXPERIMENTS

Series 1.—Obstruction of the jejunum 25 cm. below the ligament of Treitz was produced by sectioning the intestine and turning the ends in with purse string sutures. Immediately after they recovered from the anesthesia all animals were given as much solution as they would drink. Vomiting was frequent and continued throughout the experiments. The animals in this series were divided into four groups of 6 each. The first group was given tap water only, the second group 0.6 per cent solution of sodium chloride, the third group 10 per cent solution of alcohol and the fourth group a combination of 10 per cent alcohol and 0.6 per cent solution of sodium chloride.

Series 2.—Obstruction was produced at the pylorus by sectioning the pyloric ring and closing the gastric and the duodenal end with a double row of silk

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From the Department of Surgery, University of Kansas School of Medicine.

1. Carlson, H. E., and Orr, T. G.: Experimental Obstruction of the Jejunum: Effect of Administration of Water on Length of Life and Changes in Chemical Composition of Blood, Arch. Surg. **28**:292 (Feb.) 1934.

TABLE 1 (Series 1).—*Obstruction of the Jejunum 25 cm. Below the Ligament of Treitz*

Dog No.	Day After Operation	Blood: Mg. per 100 Cc. Total Non-protein Nitrogen	Blood: Mg. per 100 Cc. Chlorides (Whole Blood)	Blood: Mg. per 100 Cc. Creatinine	Blood: CO_2 Combining Power, Vol. per Cent
Group 1 (water given by mouth as desired)					
1	0	36.4	530	1.0	46.6
	2	30.9	450	1.0	57.9
	4	43.6	400	1.0	69.2
	6	44.8	385	0.9	69.2
2	0	25.3	500	1.1	46.9
	2	29.7	440	1.1	55.1
	4	31.2	380	1.0	60.7
	7	63.1	275	1.0	74.9
	9	238.0	180	1.9	69.2
3	0	27.0	495	0.9	65.5
	2	27.3	455	1.0	58.9
	4	28.9	410	1.0	68.3
	6	43.6	310	0.8	84.3
	8	85.6	220	0.9	99.4
	10	59.5	260	0.9	95.0
4	0	40.8	510	0.8	59.8
	2	24.9	430	0.8	61.7
	4	33.0	390	0.8	67.3
4	6	27.0	405	0.8	69.2
	8	40.6	340	0.9	74.9
5	0	37.0	485	1.0	42.8
	1	33.8	420	1.0	57.9
	4	35.1	415	1.0	60.7
	6	36.1	360	0.9	74.9
	8	49.2	305	0.9	83.4
	11	53.6	300	1.2	105.1
	13	48.2	265	1.1	100.8
	15	46.8	300	1.0	106.4
	18	61.8	225	1.0	102.6
	20	75.8	200	1.1	100.8
6	0	28.3	485	1.0	54.1
	2	31.9	395	1.0	55.1
	4	28.9	410	0.9	65.5
	6	28.5	370	1.0	72.1
	8	37.5	350	1.0	78.7
	11	30.0	295	0.9	83.4
	13	24.6	260	1.0	78.0
	15	63.1	250	1.0	77.7
Group 2 (0.6 per cent sodium chloride given, as much as animal would drink)					
1	0	25.7	510	1.1	45.7
	2	28.5	410	1.1	70.2
	4	34.3	380	1.1	80.6
	6	34.3	410	1.1	76.8
	8	43.2	350	1.1	84.3
	10	32.8	260	1.2	86.2
	12	53.6	305	1.0	90.0
	14	43.6	330	0.9	92.2
	16	35.5	320	0.9	98.8
	18	33.0	320	1.0	97.0
	20	27.3	385	0.9	81.8
2	0	35.5	500	1.1	44.7
	2	33.3	425	1.3	62.6
	4	34.5	440	1.1	64.5
	6	30.3	480	1.1	62.6
	8	32.3	495	1.2	60.7
	10	33.2	450	0.9	68.3
	12	42.2	425	1.2	66.4
	14	136.3	395	1.4	89.0
	16	73.9	405	1.1	87.6
	18	145.7	415	1.2	85.6
3	0	30.7	460	1.2	55.1
	2	37.0	430	1.0	63.6
	4	27.8	490	1.0	63.6
	6	31.2	475	0.9	62.6
	8	29.4	450	1.0	70.2
	10	40.0	425	0.9	76.2
	13	37.0	445	1.1	70.6
	15	36.8	440	0.9	76.8
	17	30.5	445	0.9	77.7
	19	33.9	425	1.0	80.6
	21	32.8	460	1.0	74.9
	24	34.5	440	1.1	75.8
	26	35.3	430	1.1	76.8
	28	30.0	450	1.0	72.1
	31	32.8	475	0.9	76.8
	33	28.1	420	0.9	73.0
	35	34.5	420	0.9	81.5
	37	37.2	430	0.9	84.3
	41	41.0	440	0.9	89.0
4	0	20.8	450	0.8	55.1
	2	27.0	440	0.9	61.7
	4	24.5	430	0.9	69.2
	6	18.2	465	0.8	69.2
	8	19.6	370	1.0	59.8
	10	16.2	480	0.9	56.0
	13	16.1	500	1.0	53.2
	15	42.2	485	1.7	49.4
5	0	26.9	530	1.0	47.5
	1	25.6	455	0.9	60.7
	4	32.8	450	0.9	62.6
	6	29.0	440	0.9	72.1
	8	35.9	410	0.8	72.1
	11	41.9	375	1.0	95.6
	13	46.8	325	1.0	95.0
	15	34.7	370	1.1	93.2
	18	35.9	360	1.0	85.6
	20	38.0	320	1.0	97.0
	22	30.0	365	1.4	80.8
	25	28.1	375	1.7	72.4
	27	26.8	380	1.0	79.8
	29	30.5	385	1.0	89.4
	32	22.9	365	0.9	74.4
	34	33.7	350	0.9	88.9
	36	17.4	300	1.0	80.0
6	0	42.1	470	1.0	53.2
	2	35.5	425	0.9	62.6
	4	33.5	510	1.1	57.0
	6	28.2	460	1.0	59.8
	8	31.2	400	1.0	66.4
	11	35.5	400	1.0	81.8
	13	31.4	430	1.0	68.6
	15	28.2	420	2.0	74.0
	18	32.5	430	1.0	73.0
	20	27.3	375	1.0	81.5
	22	36.8	425	1.0	76.2
	25	42.2	446	1.0	76.2
	27	55.9	470	0.9	63.6

TABLE 1 (Series 1).—*Obstruction of the Jejunum 25 cm. Below the Ligament of Treitz—(Continued)*

Dog No.	Day After Operation	Blood: Mg. per 100 Cc. Total Non-protein Nitrogen	Blood: Mg. per 100 Cc. Chlorides (Whole Blood)	Blood: Mg. per 100 Cc. Creatinine	Blood: CO_2 Combining Power, Vol. per Cent
Group 3 (10 per cent alcohol given, as much as animal would drink)					
1	0	38.3	500	1.2	47.5
	2	24.3	430	1.0	57.9
	4	32.6	380	1.1	68.3
	6	52.6	320	1.1	74.0
	8	81.2	300	1.0	82.5
	10	68.8	250	1.1	84.3
	12	64.5	305	1.0	88.2
	14	105.0	270	1.0	93.7
	16	103.0	265	0.9	110.2
	18	136.5	235	1.2	98.8
2	0	46.8	485	1.3	54.1
	2	57.8	480	1.2	58.9
	4	57.8	450	0.9	58.9
	7	136.5	420	1.8	65.5
3	0	31.2	505	0.9	42.8
	3	26.2	435	0.9	49.4
	5	28.5	400	0.9	55.1
	7	33.0	310	0.9	64.5
	10	50.0	310	1.0	85.2
	12	45.6	330	1.2	75.8
Group 4 (10 per cent alcohol and 0.6 per cent sodium chloride given, as much as animal would drink)					
1	0	27.0	470	1.0	41.9
	2	65.2	430	1.1	62.6
	4	28.7	485	0.8	70.2
	6	40.7	515	1.2	50.4
	8	30.5	520	1.1	59.8
	10	33.1	490	1.1	70.2
	11	35.9	480	1.0	85.2
2	0	34.3	470	1.0	50.4
	2	77.9	410	1.2	66.4
	6	51.8	495	1.1	62.6
	8	39.9	525	1.1	61.7
	10	49.0	520	1.0	59.8
	13	27.3	540	1.0	53.2
	15	25.8	550	1.2	54.1
	17	28.3	540	1.3	52.2
	20	32.1	535	1.1	57.0
	22	31.6	550	0.7	53.2
	24	29.4	475	0.8	49.4
	27	35.3	545	0.7	53.2
	29	40.6	580	0.9	49.4
3	14	88.2	300	1.0	87.2
	17	95.0	255	1.0	82.4
	19	254.2	225	2.3	63.0
4	0	30.5	525	1.0	47.5
	1	32.8	420	1.0	59.8
	4	113.2	350	0.9	60.7
5	0	33.5	490	1.0	49.4
	2	42.2	415	0.9	61.7
	4	44.7	395	1.1	66.4
	6	49.0	350	1.1	74.0
	8	122.4	275	1.1	104.1
	11	81.0	315	0.8	80.0
	13	147.0	320	1.0	80.0
	15	307.0	265	1.0	73.0
6	0	24.1	495	1.0	48.5
	3	33.5	470	1.1	60.7
	5	33.9	430	1.1	66.4
	7	47.2	430	1.1	69.2
	10	125.0	365	1.2	34.8
3	0	44.7	470	1.0	60.7
	2	33.5	340	1.1	55.1
	5	139.5	365	1.2	55.1
4	0	29.7	440	1.0	60.7
	3	30.0	450	0.7	65.5
	5	25.2	510	0.9	67.3
	7	25.9	500	0.9	66.4
	11	28.9	460	0.9	74.0
	13	76.0	430	1.2	79.6
5	0	30.3	500	1.2	44.7
	3	38.9	500	0.6	55.1
	5	34.5	540	1.0	53.2
	7	45.8	555	1.1	52.2
6	0	23.9	470	1.0	55.1
	3	34.5	445	0.9	71.1
	5	27.5	530	0.9	56.0
	7	24.2	485	1.0	66.4

sutures. The animals in this series were divided into two groups of 6 animals each, the first being given tap water only and the second an 0.85 per cent solution of sodium chloride.

Frequent determinations were made of the nonprotein nitrogen and the creatinine content and the carbon dioxide-combining power of the blood and the chloride content of whole blood throughout each experiment. An autopsy was done on each animal. Only those that were free from complications are included in this report.

RESULTS OF EXPERIMENTS

Series 1.—Obstruction of the Jejunum: Group 1 animals, those receiving water only, lived an average of eleven and one-third days. Analysis of the blood showed the typical rise in the nonprotein nitrogen content and the carbon dioxide-combining power and a marked drop in the chloride content. All determination of creatinine gave results within normal limits (table 1).

For group 2 animals, those receiving 0.6 per cent solution of sodium chloride, the average length of life was twenty-six and one-sixth days. Except in 1 animal there was no constant increase in the nonprotein nitrogen. The chloride content showed some decrease in 4 of

TABLE 2 (Series 2).—*Obstruction at Pylorus by Section and Suture of Duodenum and Stomach*

		Blood						Blood			
		Mg. per 100 Cc.			CO_2 Combining Power, Vol. per Cent			Mg. per 100 Cc.			CO_2 Combining Power, Vol. per Cent
Dog No.	Day After Operation	Total Nonprotein Nitrogen	Chlorides (Whole Blood)	Creatinine		Dog No.	Day After Operation	Total Nonprotein Nitrogen	Chlorides (Whole Blood)	Creatinine	
		Group 1 (water given by mouth as desired)									
1	0	31.4	535	1.3	53.2	3	3	53.3	295	1.3	85.6
	1	30.3	480	1.3	58.9		4	95.0	260	1.4	97.0
	2	30.5	410	1.1	64.5		5	183.0	260	2.0	91.4
	3	55.4	350	1.2	85.2						
	4	103.4	300	1.5	95.0	4	0	28.0	515	1.5	59.8
	5	124.5	250	1.5	102.6		1	33.3	465	1.4	71.1
	6	149.0	180	1.8	132.8		2	51.5	390	1.5	80.6
							4	198.0	245	2.8	95.6
2	0	35.5	490	1.3	48.5						
	1	40.6	460	1.6	59.8	5	0	26.7	513	1.3	50.4
	2	50.8	330	1.4	76.2		1	30.6	505	1.3	52.2
	3	230.0	230	1.4	95.0		2	37.0	400	1.3	71.1
	4	256.0	155	1.8	110.2		3	100.0	285	1.5	87.6
	5	135.0	30	2.0	112.0						
						6	0	26.5	535	1.2	40.0
3	0	38.5	500	1.4	44.7		1	30.7	485	1.2	50.4
	1	34.5	505	1.3	54.1		2	40.0	395	1.3	71.1
	2	48.7	390	1.4	77.7		3	83.3	310	1.4	89.4
		Group 2 (0.85 per cent solution of sodium chloride given, as much as animal would drink)									
1	0	31.9	520	1.4	56.1	4	1	31.2	460	1.4	50.4
	1	36.1	475	1.4	57.9		2	69.7	425	1.6	69.2
	2	103.4	495	1.9	57.0		3	145.0	380	1.8	71.6
	3	159.5	425	2.3	65.5		4	204.5	410	2.3	72.1
	4	240.0	460	4.6	60.7						
						5	0	37.5	530	1.5	45.7
2	0	32.6	505	1.4	46.6		1	38.7	490	1.4	54.1
	1	35.1	460	1.4	69.2		2	64.5	455	1.5	61.7
	2	57.8	455	1.3	62.6		3	98.8	455	1.4	67.3
	3	110.0	480	1.8	57.0		4	167.0	460	1.8	63.6
	4	128.0	485	2.0	61.8		5	225.0	450	2.0	78.7
							6	181.0	475	1.6	79.6
3	0	36.1	530	1.6	48.5		7	263.0	500	2.1	68.3
	1	31.4	490	1.5	58.9						
	2	65.9	415	1.7	80.6	6	0	29.5	480	1.5	50.4
	3	119.0	390	1.8	78.0		1	38.9	425	1.4	76.8
	4	195.0	430	2.4	71.6		2	81.0	380	1.7	74.0
	5	254.0	445	4.2	69.2		4	164.7	420	1.9	86.2
							5	208.0	455	3.2	64.5
4	0	30.5	490	1.3	45.7		6	271.0	500	4.1	60.7

the 6 animals, but the change was not marked. There was a rise in the carbon dioxide–combining power in all but 1 animal. There was no change from normal in the creatinine content (table 1).

Group 3 animals, those receiving 10 per cent alcohol, lived an average of twelve and one-sixth days. The blood showed an increase in the nonprotein nitrogen content and the carbon dioxide–combining power and a decrease in the chloride and the normal creatinine content (table 1).

In group 4 of this series, composed of animals receiving 10 per cent alcohol in 0.6 per cent solution of sodium chloride, the average length of life was twelve days. There were an average slight increase in the nonprotein nitrogen content of the blood, an increase in the carbon dioxide–combining power in 4 of the animals and a slight decrease in the chloride content in only 2 of the animals. The creatinine content remained within normal limits (table 1).

Series 2.—Obstruction at the Pylorus: Animals of group 1 of this series received water only. The average length of life was four and one-third days. In each animal there was a marked rise in the nonprotein nitrogen content and the carbon dioxide-combining power and a marked drop in the chloride content of the blood; there was a slight terminal rise in the creatinine content in 2 animals (table 2).

Group 2 dogs, those receiving 0.85 per cent solution of sodium chloride, lived an average of five days. The nonprotein nitrogen content showed a much more marked and rapid increase than in any other group in either series. There was a moderate rise in the carbon dioxide–combining power of the blood of each animal. The decrease in chloride content was slight in 5 animals. There was a definite terminal rise in creatinine content in all animals (table 2).

COMMENT

Previous experiments [1] have shown that dogs with an obstruction of the upper part of the jejunum live more than twice as long if permitted to drink water as desired. The experiments here recorded show that animals drinking a dilute solution of sodium chloride live more than twice as long as those drinking tap water. The average chloride content of whole blood was slightly reduced, but to a much smaller degree than in animals drinking water only. The same thing was true of animals with obstruction of both the jejunum and the pylorus. The average length of life for animals receiving 10 per cent alcohol was only approximately one day longer than for those receiving water. The addition of sodium chloride to the alcohol did not increase the length of life. The drinking of alcohol did not prevent the changes in the blood characteristic of high obstruction of the jejunum. When sodium chloride was added to the alcohol, changes were prevented in the nonprotein nitrogen and the chloride content, and there was only a slight average increase in the carbon dioxide–combining power. There was no increase in creatinine content in any group of series 1.

In series 2, with pyloric obstruction the length of life was not significantly increased by the giving of sodium chloride. It is interesting to note the great difference in the changes in nonprotein nitrogen in animals with jejunal obstruction and with obstruction at the pylorus. In the

latter the nonprotein nitrogen increased steadily until death, whereas in the former either there was no change or the average increase was small. The increase in nonprotein nitrogen was greater in animals receiving sodium chloride than in those receiving water, although the average chloride content of the blood in the former remained within normal limits. The group with pyloric obstruction which received sodium chloride showed the only constant increase in creatinine content in both series.

From these experiments it is evident that sodium chloride was absorbed from the upper part of the intestine and the stomach in cases of jejunal and of pyloric obstruction. Previous experiments indicate that life is prolonged by giving water ad libitum in cases in which the upper part of the jejunum is obstructed. In the present experiments duration of life was more than doubled when sodium chloride was given by mouth to animals with jejunal obstructions 25 cm. below the ligament of Treitz.

All animals of both series lost weight rapidly. The total loss of weight was in direct proportion to the duration of life.

CONCLUSIONS

A series of experiments on dogs with jejunal obstruction and a second series, on dogs with pyloric obstruction, are presented. In the first series, solution of sodium chloride, alcohol and a combination of solution of sodium chloride and alcohol, and in the second series, water and solution of sodium chloride were given orally, to determine their effect on the length of life and on the chemical character of the blood and the absorbability of sodium chloride in cases of obstruction, of the upper part of the bowel and of the stomach, respectively.

The life span of dogs with jejunal obstruction was more than doubled when they received sodium chloride rather than water only.

Sodium chloride when given by mouth to animals with experimental jejunal obstruction was absorbed in sufficient quantity to maintain the chloride content of the blood at an average level just below normal. When water alone was given, there was a marked and constant decrease in the chloride content.

Alcohol and a combination of alcohol and sodium chloride when given by mouth did not appreciably lengthen the life of the animals. In the group receiving the added sodium chloride chemical changes in the blood characteristic of untreated jejunal obstruction were prevented.

In dogs with pyloric obstruction the drinking of solution of sodium chloride produced a greater increase in the nonprotein nitrogen content than did the drinking of water. This is in direct contrast to the effect

of sodium chloride on dogs with jejunal obstruction. The chloride content of the blood showed only a slight decrease below normal when sodium chloride was given, as compared with a marked decrease when water was taken. The typical increase in the carbon dioxide-combining power was evident in dogs receiving water, but there was only a slight increase when sodium chloride was given. The constant increase in creatinine content in dogs receiving sodium chloride was striking, since it did not occur in any other group. The rise in the nonprotein nitrogen and in the creatinine content in dogs with pyloric obstruction which were given sodium chloride by mouth indicated that sodium chloride did not offer the same protection against these changes in animals with this type of obstruction as in those with obstruction of the jejunum.

LEUKOCYTE EXHAUSTION FOLLOWING SURGICAL PROCEDURES

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It is often baffling to the surgeon when after an operation a patient takes an unexplained turn for the worse or follows a progressively downhill course without apparent reason. I have recently observed that in association with such a course examination of the blood frequently shows leukopenia, with a normal differential count and a marked shift to the left of the neutrophils. This picture signifies a wearing out of the leukopoietic power and offers an explanation of the patient's lack of response to ordinary measures. This leukocyte exhaustion always indicates a serious prognosis and is probably more common than is generally realized. It therefore, I believe, deserves more recognition as a complication following surgical procedures.

Leukocyte exhaustion was first described by Turk [1] in 1907 and is usually considered as due to the "overwhelming irritation" of severe sepsis (Schilling [2]) or to "long continued infection as the result of a persistent drain" (Piney [3]). The bone marrow is usually hyperplastic, with an abnormally large number of myeloblasts and immature neutrophils. Gelatinous degeneration and a picture of almost complete aplasia may also occur.[3] Whether the damage, however, is primarily to the bone marrow or to some earlier link in the hemopoietic chain is not as yet known.

I shall present 7 cases in which leukocyte exhaustion occurred. In all there was the characteristic leukopenia, with a marked shift to the left of the neutrophils. In more than half of the cases the degree of sepsis did not appear sufficient to have exhausted a normal leukopoietic power. It may be assumed, therefore, that in these cases the leukocyte reserve was at an abnormally low level before operation. The term "low leukocyte reserve" will be used to designate this condition and to

1. Turk, W.: Septische Erkrankungen bei Verkümmerung des Granulozytensystems, Wien. klin. Wchnschr. **20**:157 (Feb. 7) 1907.

2. Schilling, V.: The Blood Picture and Its Clinical Significance, St. Louis, C. V. Mosby Company, 1929, pp. 149-154 and 180.

3. Piney, A.: Recent Advances in Hematology, Philadelphia, P. Blakiston's Son & Co., 1931, pp. 146 and 162.

differentiate it from Doan's[4] "low marrow reserve," in which agranulocytosis rather than leukocyte exhaustion develops.

I have separated the cases into two groups, depending on whether the leukocyte reserve is considered to have been normal or low. In group 1 are 3 cases in which overwhelming or prolonged sepsis was necessary to cause the exhaustion, i. e., cases in which there was a normal leukocyte reserve. In group 2 are 4 cases in which the same picture was brought about by a lesser degree of strain, i. e., cases in which there was a low leukocyte reserve.

GROUP 1: LEUKOCYTE EXHAUSTION IN CASES IN WHICH THERE WAS A NORMAL RESERVE

CASE 1.—J. H., a man aged 33, was admitted to the Crouse-Irving Hospital on July 6, 1937, with severe abdominal pain of three days' duration. The onset of the severe pain had been sudden, and aside from some abdominal discomfort during the previous week the past history was not significant.

TABLE 1.—*Blood Counts in Case 1*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes, per Cent	Monocytes, per Cent	Nonfilamented Neutrophils, per Cent*	Comment
7/7	4,950	78	21	1	88	Liver extract (twice)
7/8	6,100	93	7	0	89	Liver extract (twice)
7/9	15,650	74	26	0	80	Terminal count

* Figures indicate percentage of total number of neutrophils.

Directly after admission a laparotomy was performed, but the patient's condition was so precarious that the exploration was interrupted and the abdomen closed with drainage. Later in the day cyanosis developed, and evidence of bronchopneumonia was present at the bases of both lungs. In spite of supportive measures, the downhill course continued, and death occurred on the morning of the third postoperative day.

A blood count on the day after operation showed the characteristic picture of leukocyte exhaustion. The total count was 4,950 per cubic millimeter, with 78 per cent neutrophils, 88 per cent of which were nonfilamented (table 1). Four injections of 3 cc. liver extract (concentrated) were given, but because of the rapidity of the downhill course, I shall attempt no interpretation of the results of therapy.

Necropsy revealed a perforated duodenal ulcer on the anterior surface of the duodenum, acute generalized fibrinous peritonitis and bilateral bronchopneumonia. Smears from the rib marrow showed marked hyperplasia of the myeloblasts, with few adult cells and even myelocytes.

Comment.—In this case there was no reason to suppose that the leukocyte reserve was abnormal before operation, the degree of sepsis having been sufficiently severe to account for an "overwhelming" of the hemopoietic system. Not only was generalized peritonitis present for probably three full days, but there had been an abdominal operation and beginning pneumonia.

4. Doan, C. A.: The Neutropenic State: Its Significance and Therapeutic Rationale, J. A. M. A. **99**:194 (July 16) 1932.

Case 2.—N. R., a man aged 44, was admitted to the Hospital of the Good Shepherd, Syracuse University, on April 23, 1934, because of the recurrence of an appendical abscess. Six months before, the abscess had been opened and drained. The leukocyte response at that time was apparently adequate, and convalescence progressed satisfactorily.

Two weeks after admission a fistulous tract was excised and a large amount of pus drained from the right colic gutter and cecal area. In spite of this, the temperature continued elevated for over three weeks before finally falling to normal. Seven weeks later the temperature again rose, and after five weeks of almost continual fever an extensive lumbar abscess was opened and drained. The fever persisted, however, and when leukocyte counts were next taken, on September 5 and September 11 (table 2), a picture of leukocyte exhaustion had developed.

From this time on the patient began to lose ground even more rapidly, and his weakness finally became so alarming that a blood transfusion was given. After a period of temporary improvement, during which the leukopenia continued though the percentage of immature forms was lower (September 18, table 2), the temperature again became elevated. This time administration of powdered liver extract in doses of 1 drachm (3.88 Gm.) twice daily was started and continued until the patient was discharged. In two days the temperature was again normal and continued so. The leukopenia promptly disappeared, and the percentage of stab neutrophils remained only moderately elevated. The general condition improved rapidly, and the patient was discharged from the hospital on October 23, just six months after admission.

Table 2.—*Blood Counts in Case 2*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes, per Cent	Monocytes, per Cent	Eosinophils, per Cent	Basophils, per Cent	Nonfilamented Neutrophils, per Cent	Comment
4/25	12,000	80	17	3	0	0	18	
5/ 4	.....	..	..	..	..	..	..	Recurrent appendical abscess drained
5/ 7	7,600	80	14	4	2	0	..	
8/ 6	14,300	78	16	6	0	0	..	
8/14	.....	..	..	..	..	..	..	Lumbar abscess drained
9/ 5	4,400	57	27	13	3	0	..	
9/11	4,200	53	46	0	1	0	87	
9/16	.....	..	..	..	..	..	..	Blood transfusion
9/18	3,200	61	32	6	1	0	41	
9/20	.....	..	..	..	..	..	..	Administration of powdered liver started
9/21	5,500	58	30	10	1	1	55	
9/24	6,300	63	37	0	0	0	..	
9/30	5,100	51	44	5	0	0	51	

Comment.—The blame for the leukocyte exhaustion in this case can certainly be placed on "long continued infection as the result of a persistent drain." Except for approximately six weeks between operations, the temperature was elevated daily for over five months. The leukocyte picture at the time of admission shows an adequate reaction as regards both the total count and the maturity of the neutrophils (table 2), which is added evidence that the breakdown occurred in a previously healthy hemopoietic system.

Case 3.—H. N., a woman aged 23, was admitted to the Hospital of the Good Shepherd, Syracuse University, on Aug. 8, 1934, with diarrhea and intermittent pain in the lower part of the abdomen of four days' duration. Because of

indefinite abdominal findings and a history of drinking well water, the patient was suspected of having typhoid and was treated accordingly. Six days later, however, signs of peritonitis developed, and at operation a ruptured appendix was removed and the abdomen drained.

For the first week postoperatively the patient did well, the temperature falling from 104 F. to nearly normal and the purulent discharge from the wound decreasing. During the next two weeks, however, the condition became progressively worse, with the temperature steadily rising and the profuse discharge from the abdomen continuing. On the eighteenth postoperative day exploration for a suspected subphrenic abscess was unsuccessful, and three days later the patient died. Three blood transfusions were of only transitory benefit.

Three leukocyte counts were taken. The first two showed a satisfactory number of leukocytes, but the final count, with leukopenia and a marked neutrophilic shift to the left, presented the characteristic picture of leukocyte exhaustion (table 3).

Necropsy was not performed.

Comment.—This patient suffered continually for about thirty-two days from rather severe sepsis. First there had been appendicitis, next peritonitis and finally an infection at the operative wound and a draining abdominal sinus. By the time the last complications set in the leukopoietic power had become exhausted.

TABLE 3.—*Blood Counts in Case 3*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes, per Cent	Monocytes, per Cent	Nonfilamented Neutrophils, per Cent	Comment
8/ 8	13,300	90	9	1	...	
8/13	19,600	84	14	2	...	
9/ 4	4,500	80	20	0	100	Nine hours before death

Consideration of the severity of the strain and the apparent adequacy of leukocytes at the first two counts suggests the probability that a normal leukocyte reserve was present at the time of admission.

A special point in this case is that more frequent blood counts might have indicated a beginning failure at an early enough time for the administration of liver extract and blood transfusions to have proved effective.

GROUP 2: LEUKOCYTE EXHAUSTION IN CASES IN WHICH THERE WAS LOW RESERVE

CASE 4.—C. G., a man aged 44, was admitted to the Hospital of the Good Shepherd, Syracuse University, on Oct. 18, 1934, with severe pain in the lower part of the abdomen associated with vomiting and diarrhea of two weeks' duration. The illness had begun suddenly with the abdominal pain.

The patient had had typhoid fever twenty-eight years before and malaria and dysentery since that time. There had been three previous admissions. The first, six years before, had been for ischiorectal abscess, and the second, four years before, for a recurrence of the dysentery. On both occasions blood counts had shown adequate leukocytes. At the time of the third admission, two years before, the patient had been acutely ill with cholecystitis of twelve hours' duration. He was treated conservatively for three weeks, after which time an infected gallbladder was removed and a contiguous hepatic abscess drained. The interesting point in connection with this admission is that a blood count only two days

after the onset of the acute illness showed leukopenia (3,500 white blood cells, 78 per cent polymorphonuclears, 15 per cent lymphocytes and 7 per cent mononuclears). The leukopenia disappeared, however, during the interval and did not reappear either before or after the operation.

When admitted in 1934, the patient was in such poor condition that an operation was not attempted. The course was steadily downhill, and death occurred eleven days later. Table 4 clearly shows the exhaustion of leukopoiesis, a leukopenia with marked shift to the left persisting until the final count, one hour before death. One blood transfusion was given ten hours before death.

At necropsy a perforated ulcer of the cecum, acute colitis, generalized peritonitis and pulmonary congestion and edema were observed. The microscopic diagnosis was acute splenic tumor, central necrosis and fatty changes in the liver, toxic changes in the kidneys and ulcerative undermining colitis, apparently due to amebic infection. Studies of bone marrow were not made.

Comment.—I do not know, of course, how long before admission the picture of leukocyte exhaustion had been present. The cecal ulcer had undoubtedly perforated two weeks before, and peritonitis of such duration certainly constitutes an "overwhelming irritation." Two years before, however, leukopenia had been present during an attack of cholecystitis, suggesting that a low leukocyte reserve

TABLE 4.—*Blood Counts in Case 4*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes, per Cent	Monocytes, per Cent	Eosinophils, per Cent	Nonfilamented Neutrophils, per Cent	Comment
10/19	4,000	70	29	0	1	97	
10/23	3,000	60	33	5	2	93	
10/26	4,200	67	30	3	0	..	
10/28	.....	..	..	..	..	..	Blood transfusion
10/29	12,000	67	31	2	0	91	Count taken one hour before death

existed at that time. It is probable, therefore, that the leukopoietic function was still subnormal at the onset of the present illness.

It may be that in this case the many serious illnesses extending back for twenty-eight years resulted in a permanent impairment of the leukocyte reserve.

CASE 5.—B. F., a man aged 67, was admitted to the Hospital of the Good Shepherd, Syracuse University, on April 8, 1935, with severe abdominal pain, which had begun suddenly five hours before. Throughout the previous year the patient had noticed that his stools were getting smaller and occurring at more frequent intervals than usual.

The patient was found to have an annular carcinoma of the rectum, but because of the seriousness of his general condition operation was not considered. Thirty-six hours after being admitted he died. The blood count showed a typical picture of leukocyte exhaustion (table 5).

At necropsy the anatomic diagnosis was carcinoma of the rectum, perforation of the large intestine, generalized peritonitis and generalized arteriosclerosis. The significant microscopic observations were rather marked pigmentation of the liver and the spleen and rather marked hyperplasia of the bone marrow, with some apparent hemorrhage and a few adult cells of the myeloblastic series.

Comment.—The amount of strain required to bring about leukocyte exhaustion in this case was apparently small. The first blood count was taken one hour after admission, so that only six hours had elapsed since the rupture of the ulcer and

the beginning of peritonitis. Just what part the carcinoma played either in producing toxicity or in causing malnutrition can only be speculated on. Whatever the cause, the leukopoietic power of this patient must have been markedly impaired before the rupture of the ulcer. The peritonitis itself in that short time could have acted only as a "last straw."

CASE 6.—H. S., a woman aged 33 years, was admitted to the Syracuse Memorial Hospital on June 20, 1934, with symptoms of acute appendicitis. She had had four normal pregnancies, the last one six years before.

At operation bilateral acute salpingitis was found. The abdominal contents were not disturbed, and the wound was closed without drainage. At first the patient did well, but on the second postoperative day there were marked abdominal distention and vomiting. Although a blood count at the time of admission had shown an adequate number of leukocytes, one taken at this time showed the characteristic picture of leukocyte exhaustion (table 6).

TABLE 5.—*Blood Counts in Case 5*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes, per Cent	Monocytes, per Cent	Nonfilamented Neutrophils, per Cent
4/8 a.m.	2,100				
4/8 p.m.	3,600	70	24	6	93

TABLE 6.—*Blood Counts in Case 6*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes and Monocytes, per Cent	Eosinophils, per Cent	Basophils, per Cent	Nonfilamented Neutrophils, per Cent	Comment
6/20	16,400	94	6	0	0	..	Admission
6/21	.....	..	..	..	..	..	Operation
6/22	3,000	82	18	0	0	73	Liver extract and blood transfusion given
6/23	3,200	67	32	1	0	89	
6/24	3,500	65	35	0	0	74	Liver extract
6/25	5,500	72	28	0	0	53	Liver extract
6/26	6,800	82	16	2	0	37	
6/28	10,200	70	29	1	0	37	
7/ 6	5,300	57	41	2	0	39	
7/11	6,800	58	42	4	1	38	Discharge

One dose of 3 cc. of liver extract (concentrated) was given and followed by a blood transfusion. By the morning of the next day the distention had subsided, and recovery continued uneventfully. The picture of exhaustion persisted for several days, a return of the blood count to normal following two more injections of liver extract (table 6). Between the time of the operation and the next leukocyte count 30 cc. of a derivative of sulfanilamide known as prontosil (the disodium salt of 4-sulfamidophenyl-2′-azo-7′-acetylamino-1′-hydroxynaphthalene-3′,6′-disulfonic acid) and 45 grains (2.91 Gm.) of sulfanilamide had been administered. With the discovery of leukocyte exhaustion, however, this treatment was discontinued.

Comment.—The initial response to the salpingitis and the localized peritonitis seemed to have been entirely adequate, but the added strain of the abdominal operation was apparently too great for the hemopoietic system. The use of sulfanilamide and its derivatives is not considered a factor in leukocyte exhaustion, the only white cell dyscrasia as yet reported following such medication being

agranulocytosis.[5] It is probable, then, that a low leukocyte reserve existed prior to the onset of the present illness and that in this case the "last straw" was the operation.

CASE 7.—K. B., a woman aged 34 years, was admitted to the Syracuse Memorial Hospital on Jan. 3, 1936, for her second delivery. Her first pregnancy, four years before, had been complicated by influenza and bilateral otitis media and the puerperium by a mastoiditis requiring mastoidectomy. The leukocyte count on the first day post partum had shown an adequate number of leukocytes (15,700, with 87 per cent polymorphonuclears), but at the time of the mastoidectomy, one month later, the count had been only 6,500 per cubic millimeter, with 59 per cent polymorphonuclears.

The second pregnancy and delivery were uneventful. On the third day post partum, however, the abdomen became distended, and vomiting began. The distention continued to increase until four days later, when peristaltic waves were observed, and a laparotomy was performed. At operation the colon was found to be greatly distended as far as the splenic flexure, and the angulation at that

TABLE 7.—*Blood Counts in Case 7*

Date	Leukocytes	Neutrophils, per Cent	Lymphocytes and Monocytes, per Cent	Eosinophils, per Cent	Basophils, per Cent	Nonfilamented Neutrophils, per Cent	Comment
1/ 4	7,000	71	26	3	0	..	First day post partum
1/10	3,500	74	23	3	0	91	Operation; liver extract given
1/11	4,300	70	29	1	0	87	
1/12	5,900	74	25	1	0	51	Liver extract given
1/13	6,700	80	18	2	0	43	
1/14	7,100	72	25	3	0	26	Liver extract given
1/15	7,200	74	24	2	0	28	
1/16	7,000	68	30	2	0	43	
1/17	8,300	68	29	3	0	28	
1/18	6,900	66	34	0	0	29	
1/19	5,900	61	35	4	0	16	
1/20	5,300	55	40	5	0	31	
1/25	12,400	90	8	2	0	58	Liver extract given
1/26	4,300	61	38	1	0	10	Menses start
1/27	4,100	40	56	1	3	20	Liver extract given
1/28	4,300	43	48	6	3	16	

point was apparently the reason for the mechanical symptoms. An appendicostomy was the only procedure undertaken and the abdomen was closed without drainage.

The leukocyte count just before operation showed a typical picture of exhaustion. The total count was 3,500 per cubic millimeter, with 74 per cent polymorphonuclears, 91 per cent of which were nonfilamented forms (table 7). Intramuscular injections of liver extract (concentrated) were begun immediately and given in doses of 3 cc. every two days for three doses.

After operation and the beginning of liver therapy the patient improved rapidly. As the distention subsided, the leukocyte count rose and the percentage of immature forms fell (table 7). Recovery was thereafter uneventful, except for a temporary recurrence of distention which coincided with the strain of premenstrual leukocytic infiltration of the uterus.[6]

An increase in the neutrophilic shift to the left was again present, though this time associated with leukocytosis instead of leukopenia (table 7). Liver

5. Borst, J. G. G.: Death from Agranulocytosis After Treatment with Prontosil Flavum, Lancet **1**:1519 (June 26) 1937.

6. Novak, E., and Telinde, R. W.: The Endometrium of the Menstruating Uterus, J. A. M. A. **83**:900 (Sept. 20) 1924.

therapy was again followed by a disappearance of the distention and a return of the leukocyte count to normal. It should be noted, however, that the premenstrual strain itself is only transitory. Nine days after the recurrence of distention the patient was discharged.

Comment.—In this case it apparently required only the demands of a normal delivery preceded by a normal pregnancy to bring on the picture of leukocyte exhaustion. This means that even at the time of the patient's admission to the hospital the leukocyte reserve was probably low. It should be recalled that during the acute mastoiditis which followed the previous delivery there were only 6,500 leukocytes per cubic millimeter—obviously an inadequate number. This suggests that a low leukocyte reserve had been present four years before.

GENERAL COMMENT

This series of cases illustrates not only the importance of leukocyte exhaustion as a complication following surgical procedures, but the possibility of its occurrence when least expected, the latter point being illustrated by the extreme variability in the degree of strain required to bring it about. On the one hand, overwhelming sepsis may be necessary, as in case 1, and on the other, merely the strain of a normal delivery, as in case 7.

Five cases have been reported recently, 2 by Rosenthal [7] and 3 by Rosenthal and Kugel,[8] in which this blood picture was observed. The condition was named "hypoleukocytic angina" to distinguish it from agranulocytic angina. In 2 cases (case 11 [7] and case 2 [8]) the exhaustion developed spontaneously, illustrating a complete lack of leukocyte reserve. In the other 3 (case 12 [7] and cases 1 and 3 [8]), it followed miliary tuberculosis, an abdominal operation and streptococcic laryngitis, respectively.

Leukocyte exhaustion, then, has already been recognized, as it occurs not only in cases of severe or prolonged sepsis but in cases of much milder strain and even in cases in which there is no strain at all. My aim is to emphasize to the surgeon the importance of keeping it in mind as a possible complication of any degree of surgical strain and of discovering its presence early. This means: (1) that leukocyte counts should be made at the time of admission and especially before operation for the detection of any immediate abnormality and for possible future comparisons; (2) that counts should be made every day or two when severe sepsis is present, in order to detect leukocyte exhaustion at an early stage; (3) that they should be made whenever a patient's condition takes an unexplained turn for the worse, especially postoperatively and in the presence of abdominal distention, even in

7. Rosenthal, N.: Hematological Aspects of Agranulocytosis and Other Diseases Accompanied by Extreme Leukopenia, Am. J. Clin. Path. **1**:7 (Jan.) 1931.

8. Rosenthal, N., and Kugel, M. A.: Hypoleucocytic Angina: An Unusual Form of Infectious Leucopenia, J. Lab. & Clin. Med. **19**:344 (Jan.) 1934.

the absence of demonstrable infection. The percentages of nonfilamented neutrophils should, of course, be determined at every count.

The steps in the process of leukocyte exhaustion are, according to Schilling,[2] as follows: First, there is the leukocytosis with neutrophilia and increasing shift to the left. With continued irritation the shift to the left becomes more marked; myelocytes appear, and the total count falls even to the point of leukopenia. If the sepsis is of long standing, the shift may be "degenerative" rather than "regenerative"—that is, show a great increase of stabnuclears without young forms. In the cases reported no attempt has been made to differentiate the "regenerative" from the "degenerative" shifts.

In both case 6 and case 7 it is interesting to note that a paralytic type of abdominal distention was associated with a picture of leukocyte exhaustion. In each case relief of the distention coincided with or was followed by a return of the blood picture to normal. This suggests that a possible relation exists between a low leukocyte reserve and a low threshold for paralytic ileus.

The treatment of leukocyte exhaustion should probably be the same whether a severe or a mild strain is required to bring it about. In the cases reported, administration of liver extract, both orally and intramuscularly, and blood transfusions appeared to be of great value if administered early enough in the course of the leukopoietic breakdown.

CONCLUSIONS

1. Leukocyte exhaustion (leukopenia with marked neutrophilic shift to the left) is an important complication following surgical procedures because of its apparent frequency and the seriousness of the prognosis.

2. Leukocyte exhaustion is usually associated with overwhelming or prolonged sepsis but may occur after mild strain, in which case a low leukocyte reserve may be assumed to have existed.

3. There appears to be a relation between leukocyte exhaustion in patients with extremely low leukocyte reserve and paralytic abdominal distention.

4. The administration of liver extract and blood transfusions appear to be effective therapeutic measures for combating leukocyte exhaustion if undertaken early and if sepsis is not too severe.

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EXPERIMENTAL ADMINISTRATION OF DUODENAL CONTENTS TO DOGS WITH ACUTE HIGH INTESTINAL OBSTRUCTION

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Attention has been called repeatedly to the similarity between the symptoms of acute high intestinal obstruction and those of duodenal fistula. Without going into a detailed review of theories as to the cause of death after high intestinal obstruction, we may say that considerable evidence has been presented that the loss of the contents of the upper part of the intestine by vomiting is a most important, or the most important, factor. The fact that dogs with a duodenal fistula suffer a rapid drop in blood chlorides, dehydration, rise of carbon dioxide–combining power and death within a few days, as shown by Eisberg [1] and by one of us,[2] strongly suggests that the loss of duodenal fluid by vomiting is of prime significance.

Although the loss of pancreatic juice alone produces symptoms the same as or similar to those enumerated above, it cannot be stated as yet that this loss of pancreatic juice is the sole cause of the symptoms produced by duodenal fistula. As pointed out by Draper Maury [3] in 1910, when an intestinal obstruction is produced in dogs above the level of the bile and pancreatic ducts the animals live for a considerable time; but when the obstruction is below this level the period of survival is only a few days. Draper also showed that if the bile duct was transplanted below the level of the obstruction there was no difference in the outcome; but when the pancreatic ducts were transplanted below the level of the obstruction "a large proportion" of the dogs lived.

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1. Eisberg, H. B.: Experimental Intestinal Obstruction, Ann. Surg. **74**: 584, 1921.

2. Hill, F. C.; Neigus, I., and Wilhelmj, C. M.: Method of Preparing Duodenal Pouches for Use in Experimental Work, J. Lab. & Clin. Med. **19**: 1126, 1934.

3. Draper Maury, J. W.: Death in Acute Intestinal Obstruction and Kindred Conditions Is Due to Physiologic Disturbance, J. A. M. A. **54**: 5 (Jan. 1) 1910.

Jenkins [4] drained the duodenum and upper part of the jejunum into the ileum and anastomosed another portion of jejunum, the lower end of which was obstructed, to the stomach. The obstructed part thus consisted of stomach and a length of jejunum which had been connected to the stomach, and the duodenal contents were drained into the ileum and not lost. He found that the dogs lived from twelve to thirty-three days, suffered a gradual loss of weight, vomited occasionally and showed a gradual fall in blood chlorides and a gradual rise in carbon dioxide–combining power. After similar transplantation of the duodenum by Eisberg and Draper [5] the dogs lived seventeen days, as compared to six days with a simple high obstruction.

Morton and Pearse [6] stated that in several operations on their patients, they performed an anastomosis between obstructed and collapsed loops of bowel, diverting the contents around the obstruction, and obtained favorable results. Hartwell, Hoguet and Beekman [7] and Haden and Orr [8] showed that in simple high intestinal obstruction in dogs life can be prolonged to as long as a month by the administration of sodium chloride. McIver and Gamble [9] and others expressed the belief that in simple obstruction the symptoms are due to gradual dehydration and to disturbance of the acid-base equilibrium. Evidence has also been produced by Elman and Hartman [10] that the loss of pancreatic juice causes death by dehydration and by the loss of base bicarbonate, and they have shown that life in such dogs is prolonged by the administration of a physiologic solution of sodium, potassium and calcium chloride. Jenkins,[11] who found that in dogs with a transplanted

4. Jenkins, H. P.: Experimental Ileus: I. High Obstruction with the Biliary, Pancreatic and Duodenal Secretions Shortcircuited Below the Obstructed Point, Arch. Surg. **19:** 1072 (Dec.) 1929.

5. Eisberg, H. B., and Draper, J. W.: Intestinal Obstruction, J. A. M. A. **71:**1634 (Nov. 16) 1918.

6. Morton, J. J., and Pearse, H. E.: Similarity in the Effect of Experimental High Intestinal Obstruction and High Complete Intestinal Fistula, Ann. Surg. **94:** 263, 1931.

7. Hartwell, J. A.; Hoguet, J. P., and Beekman, F.: An Experimental Study of Intestinal Obstruction, Arch. Int. Med. **13:** 701 (May) 1914.

8. Haden, R. L., and Orr., T. G.: Obstruction of the Jejunum: The Effect of Sodium Chlorid on the Chemical Changes in the Blood of the Dog, Arch. Surg. **11:** 859 (Dec.) 1925.

9. McIver, M., and Gamble, I. L.: Body Fluid Changes Due to Upper Intestinal Changes, J. A. M. A. **91:** 1589 (Nov. 24) 1928.

10. Elman, R., and Hartman, A. F.: Cause of Death Following the Rapidly Total Loss of Pancreatic Juice, Arch. Surg. **20:** 333 (Feb.) 1930.

11. Jenkins, H. P.: Experimental Ileus; II. High Obstruction with the Biliary, Pancreatic and Duodenal Secretions, Along with Food and Sodium Chloride Entering the Bowel Below the Obstructed Point, Arch. Surg. **25:** 849 (Nov.) 1932.

duodenum there developed a low chloride content of the blood and a high carbon dioxide–combining power, demonstrated that if in addition to the previously described operation the dogs were fed milk, cream and sodium chloride through an enterostomy opening this change in blood chemistry did not occur. These dogs lived from four days to five weeks and showed only gradual loss of weight.

In spite of the fact that the giving of chloride intravenously produces such remarkable results in prolonging the lives of dogs with high intestinal obstruction, thus far, unfortunately, no such pronounced effect has been observed in the mortality rate of human patients similarly treated. It seems evident that for human beings, at least, some other measure of treatment must be evolved.

A somewhat different approach to the problem was suggested by White and Fender [12] when they collected the vomitus from dogs with high intestinal obstruction and injected it below the obstruction through an enterostomy opening. They used only 2 dogs, 1 of which lived a month and the other two weeks. No signs of toxemia developed.

EXPERIMENTS

Because there are certain difficulties which arise when one attempts to collect vomitus from dogs and which will be mentioned later, we have chosen what we believe to be a more direct approach to the problem.

We have introduced duodenal contents into the intestine below the level of a high obstruction in a series of dogs, in order to determine the importance of duodenal juices in prolonging life. A total of 12 dogs was used, 4 of which served as controls. In all the animals an enterostomy was performed by dividing the duodenum below the lower pancreatic duct, bringing out the distal end and closing the proximal end by inversion and suture. The duodenal contents were obtained from additional dogs used as donors, by performing gastrostomy and passing a duodenal tube through the opening into the duodenum. These dogs were trained to lie quietly on a table for hours at a time, and in most cases a fairly free flow of duodenal juices could be obtained, particularly if a small amount of tenth-normal hydrochloric acid was injected through the duodenal tube from time to time.

Of the 4 control animals, 2 received from 600 to 800 cc. of physiologic solution of sodium chloride a day by hypodermoclysis, 1 received 300 cc. of this solution through the enterostomy opening and 1 received no fluid. The duration of life was from two to seven days with an average of four and three-fourths days, the dog which lived longest being the one which received no fluid. The other 8 animals received from 250 to 300 cc. of duodenal juice a day through the

12. White, J. C., and Fender, F. A.: Cause of Death in Uncomplicated High Intestinal Obstruction: The Experimental Evidence to Show That Death Is Due Not to Toxemia, But to the Loss of Digestive Fluids and Salts, Arch. Surg. **20**: 897 (June) 1930.

enterostomy opening, and 600 to 800 cc. of physiologic solution of sodium chloride was administered by hypodermoclysis. These dogs lived from two to thirteen days, with an average of four and one-half days. Vomiting occurred in only 2 cases among the 12 dogs, and in these was only occasional and the amount of vomitus was small. Of the entire series of dogs, death was due to peritonitis in 3. In all the others no gross pathologic conditions could be demonstrated except that the intestine distal to the obstruction was contracted and there was considerable fluid in the stomach.

Because of the negative results of these experiments, another series of 6 dogs was used. In these animals 350 to 400 cc. of the duodenal contents of freshly killed hogs was injected daily through the enterostomy opening. No injections of saline solution were given in this series. The animals lived from two to four days, with an average of three days, and the observations were negative at necropsy in all dogs except 1, which probably had early peritonitis.

COMMENT

In considering the data which we have obtained we note two striking features: The first is that although physiologic solution of sodium chloride was given in reasonable amounts the lives of these dogs were not conspicuously prolonged. The animals differed from those of previous investigators in having an enterostomy opening in addition to an obstruction. However, because the duodenum was obstructed above this opening there was no possibility that the contents of the upper part of the duodenum would be lost. In addition, the fistula was of the nonleaking type, being so connected that peristalsis would tend to prevent leakage from it. One would not have expected this to affect materially the duration of life. The second rather surprising feature was the fact that vomiting occurred so seldom. In man the most conspicuous feature of an obstruction which has been present for several hours is vomiting—profuse, frequent and stercoraceous. In our dogs vomiting was rare, and never did it approach the human type. It is evident, then, that any attempt to use vomitus in the therapy of obstruction is attended by no inconsiderable difficulty.

CONCLUSIONS

From the experiments conducted we believe the following conclusions may be drawn:

1. Duodenal content administered to dogs through an enterostomy opening below the level of a high intestinal obstruction is not effective in prolonging life.

2. Physiologic solution of sodium chloride administered by hypodermoclysis to dogs with duodenal obstruction and an enterostomy opening does not prolong life.

3. In dogs with duodenal obstruction if nothing is given by mouth vomiting occurs only rarely.

4. The average duration of life with duodenal obstruction and enterostomy is a little over four days, and at necropsy gross examination yields no indication of the cause of death.

LINGUAL THYROID

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Of the developmental anomalies of the thyroid gland, lingual thyroid is the most unusual and the most interesting. It has rarely been the privilege of one person to observe more than a few cases in a lifetime. Clute [1] mentioned but 2 cases in a series of over 8,500 cases of thyroid disease. There was incentive, therefore, for reviewing the subject after I encountered the following remarkable case:

REPORT OF CASE

A 39 year old spinster was admitted to the surgical ward on March 30, 1936, because of a tumor at the base of the tongue. Her family history and past history were not remarkable. She had always had good health until at the age of 37 menorrhagia from uterine myomas developed. Hysterectomy and unilateral oophorectomy had been performed in June 1935.

She consulted her physician in December 1934 about menorrhagia, and routine physical examination revealed a tumor at the base of the tongue. When her slightly thick nasal speech was pointed out, she stated that this might have been coming on for some years and that she had given it little attention. However, she recalled that when she was 28 her throat had been carefully examined after a fishbone had lodged there and that nothing had been said then of any abnormality of the throat or the tongue.

Outpatient Record.—In February 1935 the tumor at the base of the tongue was observed to be smooth, firm, nonmovable on the tongue and nontender. It extended across the width of the tongue and when the tongue was pulled forward largely filled the pharyngeal orifice (fig. 1). At that time a diagnosis of malignant tumor of the tongue was made, although aberrant thyroid was mentioned as a possibility. There were no symptoms or signs of hyperthyroidism or hypothyroidism, and the basal metabolic rate was —3 per cent.

During April 1935 roentgen therapy (3,360 r) was given to the tumor, and this was followed by a slight but definite decrease in its size.

In August 1935 three gold radon seeds (1.7 millicurie each) were introduced into the substance of the tumor. Six weeks later there was some local reaction, evidenced by fibrinous exudate over the tumor and by enlarged tender submandibular nodes.

In January 1936 administration of iodine (syrup of hydriodic acid) was started and continued for six weeks; there was no obvious effect on the tumor. The patient began to have a disagreeable taste, and the breath became foul. A small

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1. Clute, H. M., in discussion on Miller, R. H.: Lingual Goiter, New England J. Med. **208**:480, 1933.

necrosing point appeared on the surface of the tumor, and a probe could be passed deeply into the tumor through this point. Presumably there was a central slough resulting from the radon, and this was draining into the mouth.

Admission to Hospital (March 30, 1936).—The patient's only complaint at the time of admission was the disagreeable taste. She admitted that her tongue was slightly unwieldy and her speech somewhat thick and nasal, but she stated that she had no sore throat, difficulty in swallowing or difficulty in breathing. There were still no symptoms of diminished or excessive activity of the thyroid gland. She had lost about 20 pounds (9 Kg.) in two months, because the foul taste had caused complete loss of appetite. In general appearance she was ruddy, healthy and well proportioned. Her weight was 130 pounds (59 Kg.). The general physical examination revealed nothing unusual aside from the lingual tumor. The pulse rate was 80, the blood pressure 130 systolic and 85 diastolic and the basal metabolic rate +8 per cent. A roentgenogram showed the outline of a mass at the base of the tongue and downward displacement of the epiglottis (fig. 2). The diagnosis was lingual thyroid with central necrosis.

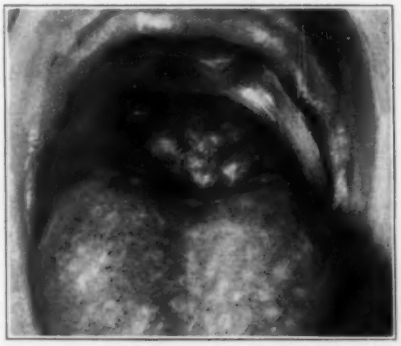

Fig. 1.—Appearance of lingual thyroid with the tongue pulled gently forward (drawing by L. Fletcher).

First Operation (April 7, 1936).—Under local anesthesia the neck was widely explored for thyroid and parathyroid tissue through a transverse incision. At the usual sites there was no glandular tissue, nor was any such found elsewhere, though the dissection was carried well below the sternal notch and above the hyoid bone. Furthermore, examination of both external carotid arteries showed no superior thyroid vessels. Recovery from the operation was prompt and uneventful.

It seemed likely that all the patient's thyroid tissue existed in the lingual tumor. Because of this, operation might have been withheld, but because of the foul odor from the necrosis, which was becoming more and more disagreeable to the patient, and because of the constant danger of hemorrhage from the same source, operation appeared unavoidable.

Second Operation (April 22, 1936).—A tracheotomy was done during local anesthesia through a small incision below the previous exploratory incision. In the next few days the patient learned to tolerate the tracheotomy tube with ease, and the tissues healed nicely.

Third Operation (May 4, 1936).—During anesthesia induced with avertin plus ether administered through the tracheotomy tube, the tumor was approached

through the mouth. The tongue was pulled forward, and soft sea sponges were placed in the pharynx to collect blood and mucus. Double medium silk sutures were placed deeply through the tongue at intervals around the base of the tumor both for traction and for temporary hemostasis. An incision widely encircling the opening of the necrotic sinus was made through the mucosa overlying the tumor. The tumor, which proved to be fairly well encapsulated, was then shelled out of its bed by combined blunt and sharp dissection. As the silk tractive and hemostatic sutures were removed, bleeding from the tumor bed was controlled by transfixion sutures of chromic catgut. Finally, the lappet of mucosa was pulled across the raw surface and sutured in place.

Fig. 2.—Lateral roentgenogram, showing the outline of the mass at the base of the tongue, which partly fills the pharynx and depresses the epiglottis. One of the three radon seeds can still be seen in the substance of the tumor.

Attempted Thyroid Transplant: Immediately after this operation was completed, several thin sections (1.5 by 5 by 5 mm.) were cut from the tumor in a region not involved by necrosis. These were passed through sterile saline solution in the hope of avoiding infection and then implanted in the rectus abdominis muscle. As feared, however, the wound soon showed evidence of infection, and the sloughing tissue extruded itself when the edges of the wound were spread on the fifth postoperative day.

Course: Aside from loss of the transplants, the early postoperative course was not unusual. The patient suffered surprisingly little discomfort from the operation,

and the tracheotomy tube was removed on the seventh day. On the morning of the ninth day bleeding appeared from the wound at the base of the tongue and increased with alarming rapidity. Conservative measures failed, and the patient went into hemorrhagic shock as she was being transported to the operating room two hours after the bleeding had started.

Fourth Operation (May 13, 1936).—With the patient in an extreme Trendelenburg position and with the tongue digitally compressed to retard the bleeding, ether anesthesia was induced with difficulty. (The tracheotomy tube, which, unfortunately, had been removed two days previously, would have served well in this

Fig. 3.—Diagrammatic section, showing the position of the lingual thyroid. Cavitation and a sinus connecting it with the mouth can be seen (drawing by L. Fletcher).

emergency.) The bleeding was largely controlled by a deep suture through the left side of the base of the tongue, but as a further safeguard against a recurrence, an incision was made in the neck and the left lingual artery ligated near its origin from the external carotid artery. The lingual artery was the first branch off the external carotid in this instance, because the superior thyroid artery, ordinarily the first branch, did not exist. After the ligation, bleeding from the tongue stopped completely and the left side blanched temporarily.

Course: After several transfusions of blood, recovery was rapid, and the subsequent course in the hospital was satisfactory. There were no signs of parathyroid deficiency, and the basal metabolic rate before discharge was —7 per cent.

Pathologic Picture.—The tumor measured 5 by 3 by 3 cm. The solid part appeared adenomatous and contained yellowish, necrotic-looking material not very suggestive of the gross picture of thyroid tissue. The cavity of the tumor measured 3 by 1.5 cm. and was filled with foul, sloughing granulation tissue (fig. 3).

Microscopically (fig. 4), the tissue near the cavity showed inflammatory changes, but sections bordering on this area had the appearance of long-standing fetal adenoma of the thyroid. In other words, the thyroid acini were lined with low cuboidal epithelium, frequently empty and widely separated by hyaline connec-

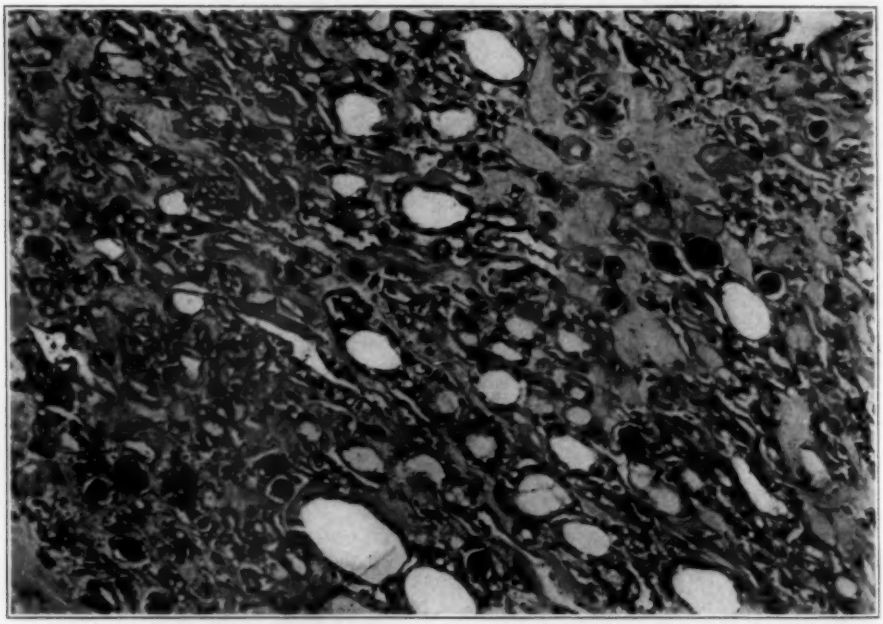

Fig. 4.—Photomicrograph showing fetal pattern of the thyroid.

tive tissue. Possibly one twentieth of the acini contained colloid material, most of which was "immature colloid." Other sections showed numerous cordlike masses of metaplastic cells of thyroid origin. Whether these represented reaction to surrounding inflammation with marked involution or early neoplastic changes was somewhat difficult to decide, but the former hypothesis seemed more tenable. No parathyroid tissue was found.

Follow-Up.—The patient has been observed at regular intervals during the fifteen months since operation. The previously thick speech soon was replaced by clear articulation. Although myxedema had been anticipated, she has steadfastly maintained that her health is excellent and she has no complaints. There has been no listlessness, no complaint of feeling cold, no falling out of hair, no dryness of skin and no inordinate gain in weight. Only after eight months was slight

puffiness noticed about the eyes. The following tabulation of the pulse and the basal metabolic rate during the period of observation indicates a gradually increasing hypothyroidism:

		Weight (Kg.)	Pulse Rate	B.M.R. (%)
Before Operation	Feb. 27, 1935	65.5	80	—3
	Apr. 2, 1936	55	84	+8
Operation	May 4, 1936			
After Operation	May 25, 1936	51	64	—7
	March 23, 1937	66	74	—17
	May 24, 1937	67	76	—18
	July 24, 1937	68	64	—19

A year after operation a small firm nodule about 6 mm. in diameter was noticed far back on the surface of the tongue; this, in all likelihood, was a residual and hypertrophied nodule of thyroid tissue.

Comment.—In this case all the patient's thyroid tissue existed in the gland at the base of the tongue. Its function was adequate, and although it had attained fair size it caused no distress. No doubt it began to grow some time after the age of 28 and might never have been noticed if it had not been found on routine physical examination. Unfortunately, it was thought at first to be a neoplasm and treated as such with roentgen rays and radium. The use of the latter was a mistake, and when it was finally appreciated that the tumor was thyroid tissue, the damage had already been done. With the fetid odor and the danger of hemorrhage from necrosis, there was little choice but to remove the gland. It may be, of course, that, even had the patient been treated conservatively with iodine and thyroid extract, continued enlargement of the gland would have necessitated operation.

The fact that myxedema did not develop within a few weeks after operation can mean only that some thyroid tissue remained attached to the tongue, and this supposition has been substantiated by the appearance of a small nodule in that region. The early signs of myxedema which are appearing after a year, however, indicate that the remaining tissue is inadequate and probably undergoing atrophy of exhaustion.

For first recording a case of lingual thyroid the credit has usually gone to Hickman,[2] an Englishman, who examined a newborn baby that had suffocated from a large thyroid tumor at the base of the tongue. In an admirable restudy of the literature, Buckman[3] unearthed an earlier account by Hunt,[4] an American, who described what must surely have been lingual thyroid, though it was not entirely recognized as such at the time. The patient was a healthy-appearing girl of 16 and had a tumor arising from the region of the foramen caecum of the tongue and filling the fauces; the tumor had been observed to grow from the size of a pea after the onset of puberty, and its description fit the classic pic-

2. Hickman, W.: Congenital Tumor of the Base of the Tongue Pressing Down the Epiglottis on the Larynx and Causing Death by Suffocation Sixteen Hours After Birth, Tr. Path. Soc. London **20**:160, 1869.

3. Buckman, L. T.: Lingual Thyroid, Laryngoscope **46**:765, 878 and 936, 1936.

4. Hunt, W.: Tumor of the Posterior Portion of the Tongue, Am. J. M. Sc. **51**:163, 1866; Tr. Coll. Physicians Philadelphia **4**:153, 1865.

ture now known. To date, about 250 cases have appeared in the literature, and even though in approximately half there have not been histologic studies, other features have been sufficient to allow the diagnosis.

DEVELOPMENTAL ANATOMY

Knowledge of the origin and development of the normal thyroid gland simplifies the understanding of aberrant thyroid tissue. Comparatively early in embryonic life the thyroid arises as an outpouching from the foregut at the level of the first pharyngeal pouches. This diverticulum becomes a sac and is attached to the pharynx by a tubular neck known as the thyroglossal duct. Though the duct eventually atrophies, its point of attachment to the tongue is permanently marked by the dimpled foramen caecum. The thyroid diverticulum is converted into a solid epithelial structure that migrates downward in the neck, where it assumes a transverse position with a lobe on each side of the upper tracheal rings (Arey [5]).

If the thyroid anlage fails to migrate or migrates incompletely, all or a part of the gland may be found anywhere between its point of origin at the foramen caecum and its normal position in the neck. The anomaly under consideration, lingual thyroid, represents persistence of thyroid tissue at its point of origin at the base of the tongue. It is to be differentiated from intralingual or sublingual thyroid, another aberrant form which appears not in the pharynx but in the submental region. In some cases all of the existing gland is present in the lingual tumor. In others the lingual nodule represents only a part of the patient's thyroid tissue, and the rest is to be found elsewhere along the tract of descent. Obviously, the removal of a lingual thyroid will vary in effect, depending on which of these two arrangements exists.

Study of the aberrant thyroid raises the question of the importance of the so-called lateral thyroids. They are known embryologically as the ultimobranchial bodies and arise in the region of the fifth pharyngeal pouches. These bodies detach, migrate caudad and normally fuse with the thyroid gland, but there is no evidence that they become glandular tissue. That they do not is supported by the fact that removal of a lingual thyroid is often followed by myxedema, which should not be the case if functioning thyroid tissue arose from the ultimobranchial bodies.

The parathyroids, which arise from the third and the fourth pharyngeal pouches, likewise fuse with the normal migrating thyroid, but

5. Arey, L. B.: Developmental Anatomy, Philadelphia, W. B. Saunders Company, 1931, p. 170.

fortunately they are not fused with the lingual thyroid. Tetany has not been known to follow removal of a lingual thyroid except in 1 case reported by Asch.[6]

INCIDENCE AND ETIOLOGY OF LINGUAL GOITER

Lingual thyroid has occurred in a female subject in 75 per cent of reported cases. It, of course, exists at birth, but its presence is seldom brought to light until later. In a few cases it has been recognized at birth or within the first year, because the size of the tumor was incompatible with life. In a majority of cases the tumor is first noticed during puberty, when its physiologic enlargement occurs. Physiologic enlargement has also been encountered during pregnancy. A striking case (reported by Rubeli [7]) was that of a woman with alarming growth of a lingual thyroid during the last months of pregnancy; a cesarean section was resorted to and was followed by prompt diminution in the size of the gland.

Increase in size of the lingual thyroid has occurred during menopause in 10 per cent of female patients. Beck [8] reported similar increase following operation for ovarian cysts, and in the case presented here there may have been some relation to the patient's pelvic disorder. Enlargement of a lingual nodule occurred in 1 case after thyroidectomy (Van Selms [9]) and in another after the pathologic destruction of the thyroid gland in the neck (Willis [10]). In a few cases this increase has been thought to be associated with trauma and it has been noticed after local and general infection.

GROSS APPEARANCE AND PATHOLOGIC PICTURE

Typically, lingual thyroid occurs as a single centrally placed tumor in the region of the foramen caecum. It is globular or hemispheroidal, with a smooth or lobulated surface, and it is covered by mucosa of the tongue, through which may be seen varying degrees of vascularity. Usually its attachment to the tongue is broad, although in a few cases it has been pedunculated. Bishop [11] reported 1 case in which there was such a narrow stalk that removal was simply accomplished with a

6. Asch, R.: Lingual Goiter, with a Contribution to Myxedema and the Question of Postoperative Tetany, Deutsche Ztschr. f. Chir. **130**:593, 1914.

7. Rubeli, H.: Lingual Goiter and Pregnancy, Monatschr. f. Geburtsh. u. Gynäk. **52**:295, 1920; abstracted, J. A. M. A. **77**:78 (July 2) 1921.

8. Beck, J. C.: Surgery of the Tongue, Ann. Otol., Rhin. & Laryng. **27**:27, 1918.

9. Van Selms, cited by Buckman.[3]

10. Willis, R. A.: Compensatory Hyperplasia of Accessory Lingual Thyroid, J. Coll. Surgeons, Australasia **3**:257, 1930.

11. Bishop, F. J.: Lingual Thyroid, Ann. Otol., Rhin. & Laryng. **43**:294, 1934.

snare. The color varies from light pink to dusky red, depending on the vascularity. The growth is firm and elastic to the examining finger and may vary from an almost invisible nodule to a mass big enough to fill the pharynx and depress the epiglottis (fig. 3). Large lingual thyroids have been described as of the size of a hen's egg or even of an apple, although the usual comparison has been to a walnut. As with other organs, size is no index of function, nor does it give any clue to the presence or absence of thyroid tissue elsewhere. Both large and small lingual thyroids have been found in cretins, and comparatively small ones have been encountered in normal persons who have no other thyroid tissue.

The histologic structure in the majority of instances is like that of normal thyroid tissue, but in about 20 per cent (Montgomery [12]) there is a fetal pattern in which there are areas of solid cell nests and numerous small acini containing little or no colloid. Cystic and other types of degeneration are not uncommon and are to be expected in the large lingual glands in cretins. At least 2 cases in which there were malignant changes are on record (Tyler [13]; Ashurst [14]); in both of these the patient was a man. In other cases in which the condition was reported as malignant, the data are not entirely convincing, and it is well to remember that benign fetal adenoma having a poor capsule next to the tongue may closely resemble a rapidly growing and invasive malignant growth.

A similar difficulty has been encountered in determining the presence or absence of parathyroid tissue. Wood [15] reported 2 cases of lingual thyroid in which there were fragments of tissue "resembling parathyroid." In discussion Ewing stated the belief that it was impossible to distinguish between young thyroid tissue and parathyroid tissue. The presence of parathyroid bodies would be difficult to explain from an embryologic standpoint; yet the case reported by Asch seems authentic enough, since tetany developed after removal of a lingual thyroid.

CLINICAL FEATURES

The symptoms may be trivial or even absent, particularly if the lingual thyroid is small and the secretory function adequate. If the growth is large, it is prone to cause difficulty in speaking, breathing

12. Montgomery, M. L.: Lingual Thyroid, Tr. Am. A. Study Goiter, 1935, p. 145.

13. Tyler, A. F.: Carcinoma of Lingual Thyroid with Metastasis in Lungs, J. Radiol. **4**:381, 1923.

14. Ashurst, A. P. C., and White, C. Y.: Carcinoma in Aberrant Thyroid at Base of Tongue, J. A. M. A. **85**:1219 (Oct. 17) 1925.

15. Wood, F. C.: Thyroid and Parathyroid Tumors of the Tongue, Proc. New York Path. Soc. **16**:84, 1916.

and swallowing. Other complaints, less frequently mentioned, are pain in the throat, snoring, nonproductive cough, dry mouth, a full feeling in the throat and a constant desire to swallow. In some cases in which the tumor almost fills the pharynx, however, the complaints are minimal. Hemorrhage from the submucosal vessels has occurred in varying degrees in 10 per cent of reported cases. It has usually been the result of local trauma or ulceration, although in several cases it has been concurrent with menstruation.

One should expect, perhaps, that a gland that shows deficiency in development in one respect will show other deficiencies as well. Added to this is the fact that the position of the lingual thyroid allows for limited growth, and the gland is exposed to repeated trauma and inflammation. The incidence of nonfunctioning glandular tissue is comparatively high in cases of lingual thyroid. Frank cretinism or juvenile myxedema has been present in about 10 per cent of reported cases, and in a smaller percentage, adult myxedema has occurred.

Hyperthyroidism might reasonably occur in association with lingual thyroid, but one would expect to encounter it infrequently. Only 2 cases in which there was presumed hyperthyroidism have been reported. In Strauss'[16] case virtually the same symptoms were present after removal of a lingual gland as before, which throws doubt on the diagnosis. In Perlman's[17] case there were symptoms of mild hyperthyroidism and a palpable thyroid in the neck as well. After rest and the ingestion of iodine, the patient had no more symptoms, but there was no change in the size of the lingual nodule. The inference is that the hyperplastic thyroid tissue existed in the neck and not in the lingual nodule.

PROGNOSIS OF TREATMENT

It is of considerable importance to know whether the lingual thyroid comprises all or only a part of a patient's existing thyroid tissue. This can be determined often simply by palpation in the normal pretracheal region or in the suprahyoid or the infrahyoid region or most certainly by exploratory operation. The latter procedure, or course, need not be carried out in every case, but there need be little discomfort or danger in it. Montgomery has estimated that in from 65 to 75 per cent of cases there is no other functioning thyroid tissue.

Myxedema will surely follow the removal of a lingual thyroid if no other functioning thyroid tissue exists, and while myxedema can be fairly well controlled, it is not a condition to be induced without good reason. If there is no pressing indication for removal, therefore,

16. Strauss, M.: Thyroid Tumor of the Tongue, Med. Klin. **2**:1259, 1906.
17. Perlman, H. B.: Lingual Thyroid Gland, Arch. Otolaryng. **19**:594 (May) 1934.

conservative treatment is advisable. Particularly when physiologic hypertrophy occurs during puberty or pregnancy, it would seem wiser to try the effect of iodine and thyroid whenever possible. Even roentgen radiation, carefully used, may be of value, but the case presented here demonstrates the dangers of radium.

The indications for operative removal of a lingual thyroid can be listed as follows: (1) the presence of other functioning thyroid tissue; (2) undue embarrassment in speaking, swallowing or breathing; (3) repeated or dangerous hemorrhage; (4) uncontrollable hyperthyroidism; (5) degeneration with necrosis and (6) suspected malignant changes (the incidence is probably high in male subjects.).

Operation.—When removal is indicated, the method of operative procedure requires careful planning for the individual case. Various lateral approaches have been utilized, but a transbuccal approach appears simpler and more direct. The operation to be described has occasionally been modified to include splitting the tongue longitudinally in the midline, which would appear to be a reasonable variation in case the tumor is unusually large or deeply embedded in the tongue. With a large tumor, the safety and the facility afforded by a preliminary tracheotomy far outweigh the few disagreeable features. It has been the experience of most surgeons that the thyroid is well encapsulated except at its attachment to the tongue, and removal has been comparatively simple. The blood supply to the lingual thyroid comes from the lingual arteries, as demonstrated in this case by the absence of the superior thyroid arteries and by the control of hemorrhage by ligature of the lingual artery.

Subtotal removal has been suggested as a means of preventing myxedema, and it is likely that this has unwittingly been accomplished in some of those cases in which postoperative myxedema has not developed. However, the incidence of recurrence of the lingual tumor in these same cases has been estimated at about 12 per cent. The most reasonable policy is to operate only when there is sufficient indication and then to attempt total removal. If myxedema follows, the patient can be given regular doses of thyroid, and the recent work of Stone, Owings and Gey [18] has given new hope for the use of grafts of thyroid tissue.

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18. Stone, H. B.; Owings, J. C., and Gey, G. O.: Living Grafts of Thyroid and Parathyroid Glands, Surg., Gynec. & Obst. **60**:390, 1935.

RIGHT PARADUODENAL HERNIA

A CASE FAVORING THE THEORY OF TREITZ

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The subject of paraduodenal (internal or mesentericoparietal) hernia is one which has always greatly interested any physician fortunate enough to encounter the condition.

The first report of right paraduodenal hernia was given by Klob in 1861. Nagel in 1923 collected the 29 cases reported up to that time. Exner in 1933 added the 11 authenticated cases reported in the interim, including his own. Novak and Sussman's case was not accepted by Exner, Averbach or us. Since that time 3 further cases have been reported (by Halliwell in 1934, by Bryan in 1935 and by Averbach in 1937), which with the case now being reported bring the total up to 44.

Exner summarized the history of these hernias and segregated them into three periods, as follows:

Period	Cases Reported	Cases in Which Operation Was Done	Cases of Recovery	Correct Preoperative Diagnosis
1861-1903	19	4	1	0
1904-1923	10	8	1	0
1924-1933	11	11	9	2

Since Exner's paper, including this case, 4 cases have been reported; 4 patients have been operated on; 4 patients have recovered and 1 partially correct preoperative diagnosis has been made (Halliwell).

From 1861 to 1923, 29 cases had been reported, with only 2 recoveries. From 1924 to 1937, 15 cases have been reported, in all of which operation was performed and in 13 of which the patients recovered. In addition, during the latter period, 2 correct preoperative diagnoses and 1 that was partially correct have been made.

ETIOLOGY

The cause of paraduodenal hernia has been the subject of wide discussion. The earlier and more generally accepted theory is that of Treitz. Treitz contended that a loop of small intestine insinuates itself into one of the peritoneal fossae at the duodenojejunal juncture and that owing to variations in intra-abdominal pressure the fossa becomes enlarged until a retroperitoneal hernia is formed. In 1923 Andrews suggested that the condition is a congenital anomaly. He stated that it

is due to incarceration during fetal life of the small intestines behind the leaves of the mesentery of the colon. These leaves are thereby prevented from becoming obliterated by fusion against the posterior parietal peritoneal wall.

The case here to be reported lends strong support to the theory of Treitz. In this case the first orifice of the hernial sac was in the usual place for a right paraduodenal hernia, that is, on the left side of the mesentery. A second hernial orifice was found in the lateral parietal peritoneum which extends between the ascending colon and the lateral abdominal wall. The hernial sac had pushed down through the first hernial orifice and had progressed retroperitoneally toward the lateral abdominal wall. It had pushed anteriorly on the parietal peritoneum which runs between the ascending colon and the anterior abdominal wall. The intestines had made and now occupied a large sac. The diameter of the sac greatly exceeded the diameter of the second hernial orifice. The ascending colon was pushed medialward. The sac consisted of two layers of peritoneum.

Any other explanation of the mechanism of formation of this hernia is difficult to understand. The fact that the diameter of the sac exceeded greatly that of the second hernial orifice shows that loops of intestine can form an intra-abdominal sac. Failure to show this has always been the greatest point in favor of Andrew's theory.

ANATOMIC CONSIDERATIONS

In this case of right paraduodenal hernia the opening of the sac was on its left side and faced left. The superior mesenteric artery ran in the neck of the sac anteriorly. Both the afferent and the efferent loop of bowel passed through the hernial orifice.

The literature states that with left paraduodenal hernia the opening of the sac is on the right side and faces left. The inferior mesenteric vein runs in the neck of the sac anteriorly. Exner stated that only the efferent loop of bowel passes through the hernial orifice.

PATHOLOGIC PICTURE

In this case adhesions were present about both hernial orifices. In some cases reported in the literature adhesions were present in the sac as well. Intestinal obstruction was not found at operation in this case, although this was the most frequent finding in the cases reported in the literature. Stenosis and also thickening of the intestinal wall have been reported.

DIAGNOSIS

A correct preoperative diagnosis was not made in this case. Only three such diagnoses have been made, and these were all made roent-

genologically. Apparently the only means by which a correct preoperative diagnosis can be made oftener is the more frequent use of roentgen studies. There were features in this case which should have aroused the suspicion of paraduodenal hernia and warranted roentgen investigation of a barium sulfate meal. The history of attacks of mild, recurrent intestinal obstruction was obtained. While a tympanic abdominal mass was not present, the history alone was sufficient to call for roentgen study.

TREATMENT

In this case the steps in treatment were: (1) Opening of the hernial sac; (2) separation of the adhesions about the two hernial orifices; (3) milking of the intestines back through the two hernial orifices; (4) excision of the hernial sac; (5) closure of the two hernial orifices, and (6) tacking of the ascending colon back into an approximately normal position.

In some cases reported in the literature the adhesions around the neck of the sac have been so great as to make it impossible to reduce the hernia. In such cases it has seemed best to enlarge the neck of the sac downward to release the constriction on the intestines and their blood supply.

In case the blood supply to the bowel were damaged the prognosis would be bad, since most of the small intestine is usually in the sac. Fortunately no such complication was encountered in this case.

REPORT OF CASE

M. M., a white woman aged 21, demanded an appendectomy on March 22, 1937.

She had been well all her life until July 4, 1930. While driving a car at a speed of 38 miles per hour she lost control of the car when it hit some loose gravel. The car rolled over one and a half times, and the steering wheel struck her in the middle part of the abdomen. She had no shock and noticed only moderate abdominal soreness for a day or two.

In October 1936 she had a cramplike, rather severe pain in the lower part of the abdomen, possibly worse on the right side. It lasted three hours. A little tenderness was elicited in the right lower quadrant. A white blood count was not made. She was a little nauseated but did not vomit. She felt some soreness in the lower part of the abdomen for two days. The bowel movements were not irregular after this attack.

In January 1937 she had occasional fleeting pains in the lower part of the abdomen, but these did not interfere with her work as a university student.

On March 2 she had an attack of pain similar to the one which had occurred in October of the preceding year. The pain was probably somewhat more severe. She was a little nauseated but did not vomit. She had a sore throat and a temperature of 105 F.

The history included a tonsillectomy in 1928.

Physical examination revealed a well developed and well nourished woman 70 inches (178 cm.) in height and weighing 155 pounds (70.3 Kg.). The

temperature, the pulse rate and the respiratory rate were normal. The white blood cell count was 8,900. The abdomen was essentially normal.

The preoperative diagnosis was possible mild, recurrent appendicitis. Operation was not encouraged, but was done on March 23 because of the patient's insistence.

A large hernial sac containing about seven eighths of the small intestine occupied most of the right side of the abdominal cavity. The orifice of the sac was on the left side of the mesentery over the lumbar area and measured about 3.5 cm. in diameter. Both the afferent and the efferent loop of bowel passed through it. Along the right, anterior, free edge of the hernial orifice ran the superior mesenteric artery.

The cecum was found slightly to the right of the midline, about 2 cm. below the inferior margin of the hernial orifice. Bands were running between it and the descending colon. At this stage the appendix was removed, which was probably a technical error.

The hernial sac was now opened. No adhesions were found within the sac. Slight adhesions were present about the hernial orifice, but these were separated with moderate ease. When an attempt was made to milk the intestines back through the first hernial orifice, it was discovered that a second hernial orifice was present. This was 3 cm. in diameter and was 3.5 cm. from the inferior margin of the lateral parietal peritoneum which goes to the ascending colon. The adhesions about the second orifice were separated with moderate ease. The hernial sac was ascertained to consist of two peritoneal layers.

The small intestines were reduced back into the abdominal cavity. Both hernial orifices were closed with running sutures of silk reenforced by interrupted silk sutures, the sac of the hernia being excised. The cecum and the ascending colon were separated from the descending colon and were anchored to the lateral parietal peritoneum.

After a somewhat stormy postoperative course complicated by paralytic ileus, the patient recovered. When last seen she was well and function of her bowels was normal.

SUMMARY

The forty-fourth authentic case of right paraduodenal hernia is reported. It is the twenty-seventh case in which operation was performed and the fifteenth in which recovery of the patient occurred.

The findings in this case strongly favor the etiologic theory of Treitz.

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SIXTY-SIXTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY

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CONGENITAL DEFORMITIES

Klippel-Feil Syndrome.—To the dozen autopsy studies in cases of the Klippel-Feil syndrome Scriba and Gmelin [1] add 1 case in which Sprengel's deformity was also present, as well as a congenital malformation of the heart. The cardiac lesion was the cause of death. The authors point out that anomalies frequently associated with the vertebral synostosis which characterizes the Klippel-Feil syndrome are spina bifida occulta and coordinated malformations such as congenital elevation of the scapula and anomalies of the rib. Associated malformations of the central nervous system, of the gastrointestinal tract or of the heart and the great vessels are seldom seen. In this case both lesions were typical malformations resulting from interference with normal development at some stage. No familial history of either deformity was obtainable, although reports of other cases have demonstrated the existence of a tendency to inheritance of such lesions.

Phocomelus and Absence of the Radius.—Hill [2] reports in detail the case of a patient with hands and feet but without arms or legs (pho-

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This report of progress is obtained from a review of 142 papers selected from 186 titles relating to orthopedic surgery and appearing in the medical literature approximately between Nov. 1, 1937, and March 2, 1938.

1. Scriba, K., and Gmelin, L.: Frankfurt. Ztschr. f. Path. **50**:376, 1937.
2. Hill, L. L., Jr.: Surg., Gynec. & Obst. **65**:475, 1937.

comelus) and that of another patient with absence of the radius. He was able to find reports of only 3 cases of phocomelus in the literature. Absence of the radius is far more common. Two hundred and fifty-three instances of this deformity were reported up to 1923.

Congenital Dislocation of the Shoulder.—Cozen [3] reports in detail the history of a boy aged 4 years with a congenital dislocation of both shoulders. This condition is differentiated from injury to the shoulder at birth by the birth history, by the absence of paralyzed muscles and by the frequent presence of other deformities. In this patient there were cervical ribs, ectrodactylism, radioulnar synostoses and congenital articular rigidity. Reefing of the capsule of both shoulder joints was performed, and later a Nicola operation was required on one side because of redislocation. The boy was examined four years later and was found to have almost normal function in both shoulders. Twenty cases are collected from the literature, attesting the rarity of this condition.

Familial Dissemination of Osteosclerosis.—Busch,[4] of Copenhagen, Denmark, observed a case of Albers-Shönberg's disease and was able to discover 14 other cases in three generations of the patient's family. One year later a second case was observed, but in the patient's family no other case was discovered after careful search. The disease is distributed about equally between sexes. It is characterized by rounded areas of opacity scattered throughout the skeleton but most numerous about the epiphyses of the long bones. There are areas of whitish yellow infiltration of the skin in about one half of the patients. Pathologic study of the osseous lesions has shown hyperplasia without any inflammatory reaction. The disease is apparently an innocent anomaly of unknown cause, probably the result of faulty embryonal ossification. A review of the literature is given.

Etiology of Congenital Malformation.—Murphy [5] reviewed 130,132 death certificates of persons dying during five years in Philadelphia. Among these, 1,476 had a congenital defect. Through interviews with the families of the deceased, 45 additional cases of congenital deformity were found. The author was unable to secure any evidence that prenatal environment played a part in producing congenital deformity, as had been suggested by Mall.[6] However, there was no congenital ampu-

3. Cozen, L.: Congenital Dislocation of the Shoulder and Other Anomalies: Report of a Case and Review of the Literature, Arch. Surg. **35**:956 (Nov.) 1937.

4. Busch, R. F. B.: Acta radiol. **18**:693, 1937.

5. Murphy, D. P.: Am. J. Obst. & Gynec. **34**:890, 1937.

6. Mall, F. P.: J. Morphol. **19**:3, 1908.

tation in this group. Deformity occurred relatively twice as frequently in white persons as in Negroes. The data which the author secured point to heredity as the cause of congenital deformity. The author suggests that reproductive inefficiency was the cause, as shown by relative sterility of the parents before the birth of the deformed child, the presence of deformity in siblings, the frequency of miscarriage and stillbirth among the mothers of such persons and the duplication of defects in brothers and sisters.

[ED. NOTE.—In the two preceding reports of progress papers suggesting a hereditary cause of congenital deformity were reviewed.]

TUBERCULOSIS

Operative and Conservative Treatment of Tuberculosis of the Spine.—The results of treatment in 44 cases of tuberculosis of the spine are discussed by Finkelstein and his associates.[7] The patients, all under 20 years of age, were divided as nearly as possible into two equal groups. In one group fusion operations were performed on the spine, and in the other group conservative measures alone were employed. A period of ten years is covered. The ineffectiveness of both conservative and surgical treatment is emphasized. The average number of days of hospital care for the patients on whom operation was not performed was one thousand, two hundred and fifteen and for the patients on whom operation was performed eight hundred and seventy-six. The authors conclude that tuberculosis of the spine is a chronic disease which runs its course little influenced by the efforts of the orthopedic surgeon. The discussions form a valuable part of this paper.

Diagnosis, Course and End Results of Tuberculous Spondylitis.—Kofman [8] analyzes 303 cases of tuberculous spondylitis treated between 1924 and 1932 at the Odessa Tuberculosis Institute. He concludes that surgical treatment of spinal tuberculosis is inadequate. Prolonged immobilization and exposure to sunlight, together with general measures to improve health, have given the most satisfactory results. Operation is indicated only for the relief of spasticity and for the careful aspiration of abscesses. In a second paper the same author [9] reviews the treatment of adults with spinal tuberculosis in sanatoriums. After conservative therapy the author discharged 147 of 231 patients as improved. Of

7. Finkelstein, H.; Greenberg, B. B.; Jahss, S. A., and Mayer, L.: Operative and Conservative Treatment of Tuberculosis of the Spine: A Comparative Study, J. A. M. A. **110**:480 (Feb. 12) 1938.

8. Kofman, S. W.: Tuberculous Spondylitis, Committee of Sciences of U. S. S. R., Tashkent, 1937.

9. Kofman, S. W.: Arch. f. orthop. u. Unfall-Chir. **38**:355, 1937.

these, 114 are employed in the lighter forms of work. Sixty-six of the 231 patients died during treatment, 23 within six months of their admission to the sanatorium. Sixty-two per cent of those with closed abscesses and 47 per cent of those with open abscesses showed improvement. The commonest cause of death in patients with draining abscesses was amyloid disease (14 fatalities). Seventy-four patients had visceral tuberculosis in addition to the spinal lesion.

[ED. NOTE.—In any appraisal of end results in the treatment of tuberculosis of the bones and joints the communal standard of health must be considered. The most discouraging reports of the results of therapy come from countries where public health measures are inadequate or from the poorer districts of large cities.]

Osteitis Tuberculosa Multiplex Cystoides.—Connolly,[10] of Liverpool, England, states that multiple cystic changes in bones represent the rarest form of osseous tuberculosis. Such a pathologic change may occur in two ways: (1) there may be caseation followed by fibrous proliferation in bone, or (2) there may be absorption of bone alone. The lesions evolve slowly, and there is a marked tendency to heal. Two cases are reported in detail. In both the patient showed cystic lesions in the phalanges, with scattered lesions in other bones as well.

POLIOMYELITIS

Recovery from Poliomyelitis.—Schein [11] has followed carefully all the patients with poliomyelitis treated at the Bellevue Hospital between 1931 and 1936. Over 400 patients were seen, but if those without paralysis and those treated elsewhere are eliminated the number is reduced to 100. More than a fourth of these were in the hospital a year or longer. Fifty-six per cent of patients with paralysis limited to the trunk recovered entirely. Fifty-three per cent of patients with paralysis of an upper extremity showed complete recovery, as against 24 per cent of patients with paralysis of a lower extremity. These figures are similar to those reported by Lovett. Ten patients showed curvature, functional in 6. There was almost complete absence of severe deformity. The deformities least amenable to prevention were flail shoulder, scoliosis and disabilities of the feet. Forty-four operations have been performed on these patients, 19 being stabilizing operations on the feet. Four patients were unable to walk, and of these, 3 have died of pneumonia. Eight patients are using crutches.

10. Connolly, H. E.: Brit. J. Radiol. **11**:25, 1938.

11. Schein, A. J.: New York State J. Med. **37**:1661, 1937.

Physical Therapy for Infantile Paralysis.—Ober [12] gives a brief, pertinent discussion of the use of physical therapy in the three stages of infantile paralysis. In the first stage, i. e., from the onset of the disease to the disappearance of neural and muscular tenderness, no massage or exercise is given. Absolute rest and daily application of hot packs are insisted on, in addition to the use of whatever splints are necessary to prevent deformities. In the second stage, after all tenderness has disappeared, baking, massage and active exercise are begun. The extent of these is determined by a complete muscular examination, the results of which are recorded on special forms. During the third stage of the disease, i. e., at the end of the period of maximum recovery of power in the muscles, fixed deformities are relieved when possible, and physical therapy is employed during periods of immobilization and rehabilitation. Electricity has no place in the treatment of infantile paralysis.

Rest and Protection in Convalescence from Poliomyelitis.—Bennett and his associates [13] emphasize that positions of physiologic rest must be constantly maintained while muscles are recovering from poliomyelitis. They described various light splints which are covered with cellulose-acetate compound to increase their wearing qualities and make them waterproof. A much more detailed description of the treatment mentioned by these authors is found in the report of Kendall and Kendall,[14] with a foreword by Drs. Bennett and Johnson, in which are explained and illustrated the methods of protecting weakened muscles during exercise and during rest. A method of grading muscles in percentage of normal function is given.

OSTEOMYELITIS

Acute Hematogenous Osteomyelitis.—Robertson [15] distinguishes between osteomyelitis caused by Streptococcus and that caused by Staphylococcus by the ability of these bacteria to produce fatal septicemia (13.3 per cent for the former and 22.4 per cent for the latter, in 337 cases). In streptococcic osteomyelitis there is no necrosis of bone, whereas in staphylococcic osteomyelitis there is necrosis. No sequestrums were observed in patients surviving a streptococcic infection, whereas sequestrums were practically always seen in patients with

12. Ober, F. R.: Physical Therapy in Infantile Paralysis, J. A. M. A. **110**: 45 (Jan. 1) 1938.

13. Bennett, G. E.; Cobey, M. C., and Kendall, H. O.: Molded Plaster Shells for Rest and Protection Treatment of Infantile Paralysis, J. A. M. A. **109**:1120 (Oct. 2) 1937.

14. Kendall, H. O., and Kendall, F. P.: Care During the Recovery Period in Paralytic Poliomyelitis, Public Health Bulletin 242, United States Treasury Department, April 1938.

15. Robertson, D. E.: J. Bone & Joint Surg. **20**:35, 1938.

staphylococcic osteomyelitis. Forty-two per cent of the patients under 2 years of age recovered; of these, 80 had sequestrums. A diffusible exotoxin excreted by the staphylococcus has an extraordinarily high potency and the ability to produce necrosis. Three toxins (leukocytolysin, hemolysin and a necrotizing toxin) are combated by the patient's natural antitoxin and phagocytosis. The presence of these toxins may stimulate the production of antitoxin, which can be definitely measured in terms of antihemolytic units. Administration of staphylococcus toxoid can raise the titer of a normal person as much as 16 times, the average normal titer being less than 1 unit. Cutaneous infections, strangely, do not seem to act as efficient antigens in raising the titer. Therefore, Robertson believes not only that children with cutaneous lesions should be protected from injury or strain but that a course of staphylococcus toxoid should be given. Furthermore, the blood of all patients with chronic or healed staphylococcic osteomyelitis should be frequently investigated, and toxoid should be administered if less than 3 units of antitoxin is present. The pathologic picture of experimental and human osteomyelitis is discussed briefly by the author, who gives his observations on the signs and symptoms of the patients he has treated. Regarding treatment, Robertson feels that no help can be had from operation until pus is present, after which simple drainage may be of advantage. In the early stages, treatment consists of combating an infection of the blood and dealing with toxins and organisms present.

Acute Osteomyelitis of the Ilium.—Pique and Valls [16] review in detail the clinical histories of 6 patients with acute osteomyelitis of the ileum, who were treated in the Hospital Durand in Buenos Aires, Argentina. In 5 cases the ilium and in 1 the pubis was involved. The organism responsible was Staphylococcus aureus in 5 cases and a streptococcus in 1. The ages of the patients were from 6 to 12 years. The lesions tended to be diffuse and were first observed about osteocartilaginous junctions. The most frequent complications were suppurative arthritis involving the sacroiliac joint, the symphysis pubis and the hip joint. The local and general symptoms were similar to those of osteomyelitis elsewhere, but diagnosis was often difficult since the symptoms could simulate those of abdominal or pelvic lesions. The abscesses gravitated along fascial planes and occurred both within and without the pelvis. The commonest deformity was flexion contracture of the hip. There was 1 case of pathologic dislocation of the hip joint. Treatment consisted of local and general measures. The authors favor the use of vaccines. Early operation with wide exposure of the ilium, curettage of the lesion and packing of the wound with petrolatum gauze are advocated. There was 1 death.

16. Pique, J. A., and Valls, J. E.: Rev. ortop. y traumatol. **7**:1, 1937.

Primary Osteomyelitis in the Adult.—Leclerc [17] finds that primary osteomyelitis in adults runs a somewhat different course from that observed in children. There is often an acute infection years before the occurrence of osteomyelitis. Then there may be an infectious incident, followed by the gradual development of osteomyelitis. The clinical signs are moderate; no great change takes place in the general condition of the patient. In the bone the lesion tends to be localized, with destruction of bone and surrounding eburnation. Incision and curettage are usually followed by healing. Cases are reported to illustrate the course of the disease.

Osteomyelitis in Infancy and Childhood.—Ober [18] states that osteomyelitis is an extremely grave condition in early childhood. There is a difference in the osseous lesions in children under 2 years of age and those in older children. In infants the organism causing the disease is usually the streptococcus. There is rarely a sequestrum. The treatment consists of simple drainage. The limb is immobilized in a plaster cast with a window for dressing, which is performed weekly. Attention to the general condition of the child, particularly to dehydration, delay in operation until the general condition has improved and infrequent application of dressings have reduced the mortality from 50 to 5 per cent. In children over 2 years of age the infecting organism is usually the staphylococcus, and sequestrum formation is the rule. Treatment of these patients also usually consists of simple drainage followed by immobilization. Operation should be performed early if the general condition of the child is good. Sequestrums are often absorbed spontaneously. The various forms of osteomyelitis in children are described briefly.

MUSCULAR DISEASES

Epidemic Myalgia.—Lindberg [19] reviews the previous reports of epidemic myalgia in Sweden and records his own observations of an epidemic of myalgia in the fall of 1938. Eighty children were attacked. In most cases the disease occurred during September. The incidence was greatest at the age of 7 years. Seventy patients were under 12 years of age. Pain appeared without prodrome except slight malaise, usually in the chest or abdomen and occasionally in the neck or arms. The pain was severe. In 25 cases there was swelling of the muscles. In a number of the cases intrathoracic or intra-abdominal lesions were suspected. In most instances there was mild leukopenia; in a few leukocytosis was present, the leukocyte count being 12,000. The sedimentation rate of the blood was followed in 23 cases. A mild increase

17. Leclerc, G.: Rev. d'orthop. **25**:227, 1938.
18. Ober, F. R.: Am. J. Surg. **39**:318, 1938.
19. Lindberg, C.: Acta pædiat. **19**:1, 1937.

in the rate was observed during the course of the disease. Meningitis with increased pressure of the spinal fluid, a positive reaction to the Pandy test and increased cellular content were noticed in 5 cases. All the patients recovered promptly. The duration of symptoms was usually four or five days. No microscopic examination was made of the muscles, nor could the author find record of any pathologic study in the literature. The author believes that the disease is an acute infectious process which spreads much like influenza. The only treatment was symptomatic. All the patients recovered completely.

POSTURE

Teaching of Body Mechanics in Pediatric Practice.—Sweet [20] gives an excellent résumé of the problem of body mechanics. He has emphasized the importance of body mechanics as a part of preventive pediatrics. The mechanics of the human body at rest and in motion are reviewed and the fundamentals emphasized under four headings: (1) the part played by gravity; (2) the strength and balance of the muscles; (3) the development of deformities, and (4) body changes during normal growth and development. The teaching of proper posture is discussed, and three points are emphasized: (1) the position of the feet; (2) the rotation of the pelvis, and (3) the position of the head.

Postural Defects Related to Arthritis.—Hartung [21] states that postural defects can affect patients with arthritis in five ways: 1. Faulty posture is mechanically inefficient and requires an undue amount of energy in standing and sitting, in this way adding an extra burden to the patient. 2. It produces gastrointestinal visceroptosis and decreases the vital capacity of the lung. 3. It predisposes to pain in the lower part of the back. 4. It causes undue strain on certain joints, predisposing them to the localization of arthritis. In osteoarthritis this static trauma localizes the severe expression of the disease to the lumbosacral and the cervical region of the spine and to the knees and feet. 5. It has a depressing psychologic effect on the patient. Since chronic arthritis is a constitutional disease, until a clearer conception of its cause is obtained, the most effective treatment is that directed against the various constitutional derangements presented by the patient. The author's method of correcting faulty posture is described.

THE BACK

Source and Differential Diagnosis of Pain in the Lower Part of the Back.—The problem of location of pain in the lower part of the

20. Sweet, C.: Teaching of Body Mechanics in Pediatric Practice, J. A. M. A. **110**:419 (Feb. 5) 1938.

21. Hartung, C. F.: Arch. Phys. Therapy **18**:626, 1937.

back is approached by Steindler,[22] who abandons the old classification into the vertical units of the sacroiliac and lumbosacral and follows instead the routes of the sensory supply to the tissues of the lumbosacral region. First the territories of the posterior and the anterior primary division of the spinal nerves are differentiated, and then the ramifications of the posterior divisions and the structures which they supply are defined. The pathways of the anterior division are dismissed briefly, as they do not involve the immediate problem. Since a large proportion of the cases of pain in the lower part of the back belong to the group in which the trouble involves strictures supplied by the posterior division of the spinal nerves, this type of disorder is discussed in detail. A triad of symptoms, i. e., local tenderness, radiation of pain and faulty posture are recognized, and a series of patients who had localized tenderness and radiation of pain referred to the area of tenderness were chosen. Procaine hydrochloride was then injected into the area. Five postulates had to be met to furnish proof of causal connection between local pain and radiation. The results of the experiments showed that there was such a causal relation and that radiation of pain could be caused by an area of local pain as a reflex symptom without being caused by root compression. This theory does not eliminate true compression of the neural roots caused by special conditions.

[Ed. Note.—This is a condensed article full of important information; it should be read in its entirety.]

Alternating Scoliosis of Proved Source.—Milliken [23] reports an interesting case of alternating scoliosis in a woman 24 years of age, who had either sciatica on the left and dorsolumbar scoliosis on the right or sciatica on the right and dorsolumbar scoliosis on the left. She complained of pain in the right hip and leg as far as the knee. Roentgenologic examination showed narrowing of the body of the fourth lumbar vertebra with a spur on the upper anterior margin. Operation showed an abnormally long and hook-shaped first sacral spine, which extended upward, meeting a correspondingly long process of the fifth lumbar vertebra. The two processes were not joined but were in contact in the flexed position. Extension of the spine made the processes slip by one another, and a slight twist of the pelvis could make them overlap on one side or the other. Hibbs' fusion of the fourth and fifth lumbar vertebrae and the sacrum was followed by complete relief.

Major Injury to the Spine.—Mixter [24] gives an account of the general lines on which treatment should be carried out for severe injury

22. Steindler, A.: Differential Diagnosis of Pain Low in the Back: Allocation of the Source of the Pain by the Procaine Hydrochloride Method, J. A. M. A. **110**:106 (Jan. 8) 1938.

23. Milliken, R. A.: South. M. J. **30**:1099, 1937.

24. Mixter, W. J.: New England J. Med. **217**:899, 1937.

to the spine, beginning at the scene of the accident. For transportation a rigid dorsal stretcher is essential. With injury to the cervical or the upper portion of the spine the patient should be placed on his back; no twisting or flexing of the neck should be allowed. With injury to the dorsal or the lumbar portion of the spine the patient should be placed face downward. As soon as possible the clothing should be cut away and all causes of localized pressure removed. General treatment for shock should be instituted. When the initial shock subsides, a neurologic examination should be made to determine particularly the upper limit of any loss of power or of sensory or reflex abnormality. Roentgen examination should then be made. Time is valuable. If paralysis or neurologic signs persist after two hours, there is probably damage to the cord or the cauda equina, and lumbar puncture to determine the presence or absence of hemorrhage and the presence or absence of block in the subarachnoid space is indicated. If evidence of compression exists, the advisability of laminectomy must be decided. If the pressure is on the spinal cord, it should be relieved as early as possible, i. e., within a matter of hours; if the pressure is on the cauda equina, which is a less vulnerable structure, time is not so important. Cervical fracture with compression is a serious injury. Laminectomy further weakens the spine and causes disturbance of the heat-regulating and the respiratory mechanism. For this reason traction up to 40 or 50 pounds (18 to 22 Kg.) is preferred, and skeletal traction may be necessary. Lumbar puncture is then repeated to determine whether the compression is decreased. If laminectomy then seems indicated, it should be performed within twenty-four hours of the injury. For fracture in the dorsal region with compression and block laminectomy should be performed, since there is little fear of dislocation. The operation should take place within twenty-four hours of the time of injury. For fracture of the lumbar portion of the spine with injury to the cauda equina, laminectomy may be postponed till existing bony deformities are corrected.

Spinal Epidural Cyst with Resulting Kyphosis.—Cloward and Bucy [25] give a detailed account of a case of spastic paraplegia in a patient 16 years old. There were dorsal kyphosis and an epidural cyst, which was removed by operation. An account of 9 similar cases from the literature is given, to illustrate the progress of the deformity and the early symptoms. In all except 1 of the cases the patients were adolescent, and all presented alterations in the vertebral bodies at the level of the mass. The commonest site of the lesion was the mid-dorsal region. Kyphosis was present in every case, suggesting kyphosis dorsalis juvenilis. The authors draw attention to the predominance of motor changes and to the fact that in 3 patients no block in the spinal canal

25. Cloward, R. B., and Bucy, P. C.: Am. J. Roentgenol. **38**:681, 1937.

could be demonstrated by the Queckenstedt test. The most frequent roentgenologic changes were a defect in the anterosuperior or the anteroinferior margin of the vertebral bodies, a reduction of the intervertebral space with prolapse of the nucleus pulposus and wedging of the vertebra. In the spinal canal there may be erosion of the vertebral pedicles or a slight concavity of the posterior surface of the vertebral body. The authors believe that the cyst was an evagination of the arachnoid and the dura mater at the point of emergence of the spinal roots. The kyphosis they consider to be the result of pressure on venous channels between the dura mater and the vertebral body.

[ED. NOTE.—This interesting condition is apparently rare. The patient with kyphosis dorsalis juvenilis usually does not present neurologic disturbances in the lower extremities, nor is the roentgenologic picture similar. In this special type of disease, with epidural cysts, early recognition and operation should prevent the spinal deformity.]

Scoliosis Treated by the Wedging Jacket.—Butte [26] analyzes some of the cardinal principles of spinal fusion, with particular reference to the selection of the area to be fused, as applied in the New York Orthopaedic Dispensary and Hospital. Five cases are described, and roentgenograms are presented to illustrate the following points: 1. Every vertebra in the primary curve must be fused unless in an occasional case one of the vertebrae at one or the other end of the curve is omitted to avoid overcorrection of the secondary curve. 2. To be ideal, the area of fusion must include the minimum area of fusion (at least), and its end vertebrae must be parallel to each other and at right angles to the line joining their centers. 3. Actual determination of the area of fusion is not made until correction has been obtained by the wedging jacket. 4. Overcorrection of a curvature is avoided by the "pelvic tilt" examination described by Ferguson. During this the patient sits unassisted, with hands resting on the knees; the pelvis is elevated 3 or 4 inches (7.5 to 10 cm.) on the side of the convexity of the lumbar curve, and a roentgenogram is made. 5. Provided compensation has been restored, remarkable improvement in clinical and roentgenographic appearance often results when the primary curve has been corrected less than 50 per cent.

PERIPHERAL VASCULAR DISEASE

Treatment of Peripheral Vascular Disease.—Holman and Schulte [27] apply a suction-pressure chamber only to the thigh, where it acts as a "booster pump," drawing blood into the thigh and forcing blood into the peripheral vessels. In this way vessels which are still patent and pliable instead of obliterated or practically obliterated vessels are acted on.

26. Butte, F. L.: J. Bone & Joint Surg. **20**:1, 1938.
27. Holman, E., and Schulte, T. L.: Surgery **2**:502, 1937.

The pump can be applied in the presence of infection of the foot, without danger of spreading infection by active massage, and it is useful in cases of obliterative vascular disease, whether the condition is due to thromboangiitis or to arteriosclerosis.

Popliteal Aneurysm as a Cause of Peripheral Circulatory Disease.—Theis [28] reports 5 cases of aneurysm of the popliteal artery in which the primary symptoms were those of peripheral circulatory disease. He concluded that an aneurysm in the popliteal space should be suspected in all cases of peripheral circulatory disease. All 5 patients were men. Violent muscular effort was the probable etiologic factor in 2 cases; in the others the cause was not known. Theis believes indirect trauma, such as that resulting from forced flexion of the knee or violent muscular strain, to be the most important cause of popliteal aneurysm.

THE KNEE

Injury of the Knee Joint.—Dickson [29] gives an excellent discussion of injuries to the semilunar cartilages, the internal lateral ligaments and the cruciate ligaments. Most of the discussion concerns the semilunar cartilages and presents in detail and in clear textbook form the present day conception of the causes, symptoms, diagnosis and treatment of injuries to these structures.

THE SHOULDER

Rupture of the Supraspinatus Tendon.—Davies and Sullivan [30] report 5 cases of complete rupture of the supraspinatus tendon in which the patient was seen within seventeen days after injury. One patient was operated on five days after injury, 2 six days after, 1 thirteen days after and 1 seventy days after. All were in the sixth decade of life. The immediate trauma causing this condition was a fall in 3 cases, a blow in 1 and strain in lifting in 1. Pain was a variable symptom. The authors advise immediate repair, as the operation is easier and the end results better than when it is delayed. Immobilization in 90 degrees of abduction for three weeks after operation is the most satisfactory after-treatment.

Tears of the Supraspinatus Tendon.—Outland and Shepherd [31] give a résumé of 12 cases of operation for tear of the supraspinatus tendon. One patient was 32 years of age, but the average age for the series was 50 years. The authors stress five objective signs in making the

28. Theis, F. V.: Surgery **2**:327, 1937.

29. Dickson, F. D.: Injuries of the Knee Joint, J. A. M. A. **110**:122 (Jan. 8) 1938.

30. Davies, T. W., and Sullivan, J. E.: Ann. Surg. **106**:1059, 1937.

31. Outland, T. A., and Shepherd, W. F.: Ann. Surg. **107**:116, 1938.

diagnosis: (1) diminution or loss of power to abduct; (2) tenderness over the greater tuberosity; (3) undue prominence of the greater tuberosity; (4) crepitus, and (5) normal roentgenographic appearance. In 5 of their cases the rupture was the result of dislocation of the shoulder. Hence, they advise testing all patients with dislocated shoulders immediately after reduction. For two thirds of the patients the end results were excellent or good.

[ED. NOTE.—These two papers describe a not uncommon injury which sometimes follows insignificant trauma to elderly persons. In the sixty-fifth report of progress, in a report of a paper by Meyer, the frequent observation of this injury in the dissecting room is mentioned.]

NEOPLASMS

Solitary Bone Cyst and Giant Cell Tumor.—Discussing 6 of his 12 cases of cyst and giant cell tumor, Szanto[32] contrasts the views of European and American pathologists. He comments on the necessity of evaluating each case purely on its detailed merits. He agrees that the prognosis for giant cell tumor and solitary cyst occurring in a patient over the age of 24 often is not as benign as in the young. He also agrees that lesions on the diaphysial side of the epiphysial plate are more prone to be benign, while the prognosis of those extending on both sides of the plate site, as in older patients, is apt to be less favorable. He disagrees, however, with the American teaching that insufficient surgical intervention may change the character of the lesion and maintains that other causes must be found for progress of the lesion when progress occurs.

Cavernous Hemangioma of the Vertebral Column.—Hemangioma of bone, including that of the vertebral column, is not rare according to Yuzhelevskiy.[33] It is often not recognized clinically. The author was able to find only 34 recorded cases of hemangioma of the vertebral body which caused compression on the spinal cord. He adds reports of 3 cases in which myelitis resulted from vertebral hemangioma. The lesion was in the first lumbar, the fifth thoracic and the eleventh thoracic vertebra respectively in these 3 cases. In 2 the condition was diagnosed at operation, while diagnosis was made from the course and the roentgenologic findings before operation in 1 case. The roentgenograms show bone of cellular and spongy texture with numerous clear spaces divided by fairly thick trabeculae containing calcium. The intervertebral disks were not involved. All 3 patients recovered after operation. When the tumor cannot be completely removed because of its position, laminectomy with postoperative roentgen or radium therapy is of benefit.

32. Szanto, G.: Arch. f. orthop. u. Unfall-Chir. **38**:336, 1937.

33. Yuzhelevskiy, A. S.: Vestnik khir. **52**:164, 1937.

MISCELLANEOUS STUDIES

Os Centrale Manus, an Accessory Bone in the Hand.—In both wrists of a 14 year old girl Schneider [34] observed at autopsy a cartilaginous accessory bone, os centrale manus. This bone was boat shaped and measured 10 by 7 cm. Such a bone is uncommon, and its ossification takes place later than does that of the other carpal bones. It lay proximal to the dorsoventral canal of the carpal bones. This canal, which contains fat and ligaments, shows occasionally in roentgenograms as an indentation in the neck of the os capitatum. On one side an os capitatum secondarium was present also.

Histiogenesis of Paget's Disease.—Continuing the studies on Paget's disease begun by Erdheim and Freund, Karplus [35] studied the development of a lesion in a long bone. He points out that the lesion appears in small multiple discrete areas in the cancellous bone and cortex, which later fuse. He lists several stages. 1. In the immediate neighborhood of an adult spicule of bone a capillary enlarges; round cells appear, and the endosteum over the bone thickens. 2. Osteoclasts are visible in Howship's lacuna eroded into the old bone. 3. The lacuna is deep and is partially or completely filled with new-formed bone. The fatty marrow is replaced by fibrous marrow. These stages are observable not only in the medullary cavity but in the cortex. When the latter area is affected the capillary in the vascular canal of the haversian system undergoes the changes previously listed. Incidentally, the architecture of the new-formed bone appears to bear a relation to the stresses involved. Photomicrographs illustrate the author's explanation of these changes.

Osteochondritis of the Hip Joint.—Since October 1936 4 cases of osteochondritis dissecans of the hip were observed by Schörcher [36] in a Munich clinic. All the patients were males. In 2 the disease was bilateral. The ages ranged from 18 to 49. The duration of pain was two months for 1 patient. For the 3 other patients it was six, fifteen and 19 years, respectively. All showed the roentgenologic picture of osteochondritis dissecans. One had some acetabular changes. There was no definite history of trauma. In 1 patient a loose body was found in the hip joint. The author was unable to state what influence injury might have in the development of the lesion.

Method of Treating Ganglions.—Aspiration of the tendon sheath rather than operative removal is advocated by Bearse.[37] The aspiration

34. Schneider, H.: Wien. klin. Wchnschr. **50**:1326, 1937.

35. Karplus, H.: Frankfurt. Ztschr. f. Path. **50**:190, 1937.

36. Schörcher: Arch. f. orthop. u. Unfall-Chir. **38**:362, 1937.

37. Bearse, C.: Ganglions of Tendon Sheaths: Method of Treatment, J. A. M. A. **109**:1626 (Nov. 13) 1937.

is performed with a large bore transfusion needle, since the ordinary aspirating needle is not large enough to evacuate the gelatinous contents through its base. Aspiration is followed by tight bandaging for twenty-four hours. In some of the reported cases the condition recurred, but was cured by another aspiration. In 1 case seven different ganglions have been successfully aspirated after two operations for previously appearing ganglions.

ORTHOPEDIC OPERATIONS

Tendinoplastic Amputation Through the Femur at the Knee.—Callander [38] gives the essentials of his previously described operation for amputation of the lower end of the femur. The operation begins with creation of an anterior flap running down as far as the tibial tubercle and of a longer posterior flap. The muscles are divided through their tendinous portions, and hemorrhage is thereby lessened. The popliteal vessels and nerves are ligated through a medial approach to the popliteal space. The patella is removed, its tendon being left intact, and the femur is divided just proximal to the adductor tubercle. After the end of the bone is treated, the flaps are held together with widely spaced skin sutures. None of the deep structures are sutured. The redundant skin is rapidly drawn taut by postoperative contraction of the hamstring muscles, and the scar is converted by this pull into a posterior one. The author has recorded 80 cases of amputation by this method. Most of the patients were elderly persons (over 65 years of age). The operation was performed chiefly for vascular complications. The operative mortality was 13 per cent.

New Suture for Tendons and Fascial Repair.—Gratz [39] describes a method of suturing divided tendons whereby the strength of the internal fixation is increased. Reenforcing figure of eight sutures are placed and tied in a V behind the tendons. This allows firm, accurate apposition without danger of pulling out of the retaining sutures.

FRACTURES

The Most Resistant Fracture.—Hoffman,[40] of Geneva, Switzerland, reviews the methods of treatment for fracture of the femoral neck, giving credit to Delbet for the introduction of a screw or nail for internal fixation by a small incision over the trochanter. In discussing the problem of nutrition of the femoral head he quotes the law of Roux, of Lausanne, Switzerland: "Upon the skeletal structures, all pressure produces bone, all traction produces fibrous tissue." He believes this

38. Callander, C. L.: Tendoplastic Amputation Through the Femur at the Knee: Further Studies, J. A. M. A. **110**:113 (Jan. 8) 1937.

39. Gratz, C. H.: Surg., Gynec. & Obst. **65**:700, 1937.

40. Hoffman, R.: Rev. d'orthop. **25**:193, 1938.

law is of fundamental importance in the prognosis of fracture of the femoral neck. With recent fracture one may wait as long as ten days and correct any organic defect before considering operation. If the position is favorable for function and pressure will be exerted on the fracture by muscular pull and weight bearing, it should be maintained. In cases in which the position of the fragments is not so favorable the patient should be operated on if there are no contraindications. With the patient under spinal anesthesia, the legs are put in traction with gradual bilateral abduction. This brings the femoral neck into valgus. Over a Kirschner wire as a guide and under roentgenologic control a pin is driven into the femoral head. A pillow under the knee is the only support after operation. Active motion in bed is encouraged in one week. Early walking is permitted only in cases in which the line of fracture is horizontal. In other cases unprotected walking should be delayed four months. Pseudarthrosis is caused by failure of contact under pressure of the fractured ends. Usually in cases of nonunion simple osteotomy is performed subtrochanterically. Then an attempt is made to bring the surface of the fracture to a horizontal position.

Fracture of the Femoral Diaphysis.—Bado and his co-workers [41] review 85 cases of fracture of the diaphysis of the femur treated at the Hospital Pasteur in Montevideo, Uruguay. Skeletal traction was employed, usually through the femoral condyles. When full reduction was secured and easily maintained, a plaster spica carefully modeled to the leg was applied from the rib line to the toes. Walking in the cast was begun in six or seven weeks by adults. There were 20 transtrochanteric fractures, 57 in the shaft and 8 above the condyle. Traction was usually continued for from ten to twenty-two days. No operative reductions were performed in this series of cases.

The Discus Articularis in Colles' Fracture.—Taylor and Parsons [42] point out the importance of recognizing injury to the discus articularis at the distal end of the radius and ulna in Colles' fracture. The function of the discus articularis is to stabilize the inferior radioulnar joint. In Colles' fracture with a loss of integrity of the radioulnar joint the deformity may be due to: (1) rupture of the ligament itself; (2) avulsion of the ulnar styloid at its base, or (3) severe comminution of the lower end of the radius with the ligament attached to a loose minor medial fragment. Diagnosis is made not only by loss of integrity of the wrist but by bulging forward of the ulnar head on the ulnar aspect of the wrist and its abnormal movability in relation to the radius and the hand; also, there is marked broadening of the joint, roentgenographic evidence

41. Baldo, J. L.; Rolfi, D. V., and Pedemonte, P. V.: Rev. ortop. y traumatol. **7**:91, 1937.

42. Taylor, L. W., and Parsons, C. L.: J. Bone & Joint Surg. **20**:149, 1938.

of fracture through the base of the ulnar styloid or separation of the medial fragment of the radius. Treatment consists of prompt, accurate restoration of anatomic relations, under fluoroscopic guidance. Impaction should be broken up, and restoration of the dorsal position of the ulna should be accomplished. After the proper length and articular angle of the radius have been restored, there should be close apposition of the radius and the ulna to prevent widening of the wrist. The most stable position is extreme flexion and ulnar deviation (so-called Cotton-Loder position), which should be maintained for ten days in plaster of paris. Then the wrist should be placed in a neutral position for ten days. Disability usually lasts two months.

Isolated Fracture of the Triangular Bone.—Garraud,[43] of Lille, France, lists this fracture as rare. Fracture of the triangular bone, associated with other injuries of the hand or wrist, is seen a little more frequently. A case is reported in detail. The injury occurred in a fall on the ulnar side of the extended hand. The diagnosis can be made only by roentgenograms taken with the hand in half supination and in neutral position as regards flexion of the wrist. The fractures may occur by two mechanisms: (1) a pull through the dorsal radiotriangular ligament when the hand is in hyperflexion and radial deviation, or (2) the compression of the bone between the triangular fibrocartilage and the pisiform bone. The fracture heals readily, and rigid immobilization is unnecessary. Support with a splint during the period of swelling is all that is required. The author was able to find only 50 cases of such fracture recorded in the literature.

Fracture of a Metacarpal Bone.—Jahss [44] flexes the metacarpophalangeal joint to the involved finger 90 degrees and reduces the displacement by upward pressure. This method is used for any of the four fingers. The position relaxes the interosseous muscles and tenses the collateral ligaments. The proximal fragment is then immobilized in plaster of paris, which is allowed to dry, after which a second plaster of paris strip is applied around the flexed finger to exert a push upward to hold the reduction. The uninvolved fingers are left free.

Injury to the Upper Tibial Epiphysis in Sport.—Holldack [45] describes the occurrence of an epiphysial separation at the upper end of the tibia of a 16 year old boy during a high jump. There was a loud noise and pain while the boy was in the act of jumping. He was unable to arise from the sand pit. Roentgenograms revealed that the upper epiphysis of the tibia was separated, tilted backward and displaced slightly medially. No other pathologic condition of bone was demonstrable.

43. Garraud, R.: Rev. d'orthop. **25**:205, 1938.

44. Jahss, S. A.: J. Bone & Joint Surg. **20**:178, 1938.

45. Holldack, F.: Arch. f. orthop. u. Unfall-Chir. **38**:379, 1937.

Reduction was followed by uncomplicated convalescence. The lesion was apparently caused by muscular pull and is similar to the avulsion of the tibial tubercle in sprinters. The author was unable to find record of a similar case.

Fracture of the Os Calcis.—Yoerg [46] treats all types of fracture of the os calcis except that of the beak and simple fracture of the tuberosity by manual manipulation, with complete mobilization of the subastragalar joint. With the achilles tendon relaxed, the heel is pulled down and the disimpacted fractured bone replaced, a clamp being used. A cast is then applied; it is molded under the malleoli, over the back of the heel and under the arch of the foot, with the knee flexed and the foot in full plantar flexion. The cast is removed after one month; removal is followed by massage and active motion without weight bearing for the next four to six weeks. In the ordinary type of fracture union is complete two months after reduction.

Pathologic Fracture.—Ghormley and his associates [47] review 660 cases of pathologic fracture from the records of the Mayo Clinic and divide them into three groups. The first group consisted of fractures attributable to metastatic malignant lesions. Carcinoma of the breast was the most frequent lesion in this group, causing six times as many fractures as the next known cause, carcinoma of the prostate. The second group contained factors attributable to primary malignant lesions of the bone, the most frequent of which was osteogenic sarcoma followed by myeloma. The third group consisted of fractures caused by benign lesions, of which senile osteoporosis caused three times as many as the next disease on the list, osteitis fibrosa. The various diseases in which pathologic fracture may occur are discussed. The percentages of patients suffering from the various conditions who might be expected to have pathologic fractures are tabulated.

RESEARCH

Fractures and Vitamin C.—Lauber and his co-workers [48] produced fractures of the forelegs of rabbits in two ways: (1) by fracture of both bones subcutaneously, and (2) by open operation, a 2 mm. segment being excised from the radius. They found that on the second day there was a decrease in the output of vitamin C, indicating the need for more vitamin C. Increasing the intake of the vitamin did not hasten the healing of the fracture; however, giving less vitamin C

46. Yoerg, O. W.: Surgery **2**:493, 1937.

47. Ghormley, R. K.; Sutherland, C. G., and Pollock, G. A.: Pathologic Fractures, J. A. M. A. **109**:2111 (Dec. 25) 1937.

48. Lauber, H. J.; Nafziger, H., and Bersin, T.: Klin. Wchnschr. **16**:1313, 1937.

retarded healing. They conclude that if there is a lack of vitamin C, callus formation may be speeded up by administration of the vitamin. Callus formation was not increased by giving ascorbic acid above the normal vitamin C intake.

Calcium Tolerance Curves in Cases of Paget's Disease.—After studying the calcium tolerance curves of a series of 146 persons, including 17 patients with untreated Paget's disease and 22 normal subjects, London and Bernheim [49] conclude that in the presence of this condition there appears to be an increased affinity for calcium on the part of the bones and tissues or a decreased affinity for calcium on the part of the blood. They injected 10 cc. of calcium gluconate intravenously, withdrew samples of blood fifteen minutes and two hours later and made determinations on the serum. The curve of patients with untreated Paget's disease showed a tendency to smaller deviations than that for normal controls and that for patients with miscellaneous conditions. Five patients with Paget's disease had an almost flat curve, a result not obtained for any of the normal subjects.

Production of Osteosarcoma in the Mouse.—Brunschwig and Bissell [50] believe they have reported the first osteosarcoma experimentally produced by a clinical agent. A mixture of 1,2 benzpyrene and cholesterol injected into the intramedullary space of the mouse's tibia produced osteosarcoma in eight and one-half months.

Osseous Changes in the Fetus Produced by Calcium and Viosterol.—Fifty-eight women were placed under observation at various periods of gestation for the remainder of their pregnancy.[51] Thirty-three of them were treated with dicalcium phosphate and viosterol, while 25 served as controls. It was found that the total calcium content of the serum in the treated group increased slightly during the later part of pregnancy, while in the control group there was a definite diminution. The values for the total calcium and for inorganic phosphorus of the infants exceeded those of the mothers, and this difference was more pronounced in the treated group. There was definite evidence of increased density of bone in the majority of infants born to the treated mothers. The authors suggest that this osteosclerosis, especially in the parietal region, might possibly interfere with molding of the head, which is so often an important factor in cases of difficult delivery.

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49. London, I. M., and Bernheim, A. R.: J. Lab. & Clin. Med. **23**:18, 1937.

50. Brunschwig, A., and Bissell, A. D.: Production of Osteosarcoma in the Mouse by Intramedullary Injection of 1, 2-Benzpyrene, Arch. Surg. **36**:53 (Jan.) 1938.

51. Finola, G. C.; Trump, R. A., and Grimson, M.: Am. J. Obst. & Gynec. **34**:955, 1937.

Replacement of the Semilunar Cartilage.—Bruce and Walmsley [52] observed a partial regeneration of the internal semilunar cartilage of a football player who later injured the external semilunar cartilage in the same knee. The replacement was apparently of firm fibrous tissue. In 5 of 6 dogs from which the external semilunar cartilage was removed a similar regeneration with fibrous tissue was seen. This was an ingrowth from the articular capsule and not a growth from the remaining portion of the semilunar cartilage. The authors suggest that a more even substitution occurs when the cartilage is removed completely.

52. Bruce, J., and Walmsley, R.: Brit. J. Surg. **25**:17, 1937.

CORRECTION

In the article by Drs. Curry and Taylor, entitled "Fractures of Both Bones of the Leg," which appeared in the May issue (ARCH. SURG. **36**:858, 1938), the roentgenogram which appeared as figure 3 should have been figure 6, and that shown as figure 6 should have been figure 3.